RESEARCH PROJECTS

Funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee

1988 - 1989

Ontario

The Ontario Pesticides Advisory Committee

Jim Bradley
Minister

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FUNDED BY

THE MINISTRY OF THE ENVIRONMENT

THROUGH

THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1988 - 1989

PESTICIDES ADVISORY COMMITTEE

1988-89

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Executive Secretary to the Committee

RESEARCH PROJECTS FUNDED BY THE MINISTRY OF THE ENVIRONMENT THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1988-89

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EXECUTIVE SUMMARY

1. In 1988-89, the Ontario Pesticides Advisory Committee continued a program, begun in 1973, of funding research on pesticides. The 1988-89 objectives of the program focused on :

(a) Ways of reducing pesticide input into the environment.

(b) Minimizing risks from pesticides to the environment and human health.

(c) Enhancing the effectiveness of pest management practices.

2. The research budget was $ 400,000.

3. Fifty research proposals totalling $ 949,960 were received.

4. Twenty-nine proposals were funded with a total value of $ 392,639. Awards averaged $ 13,539 and ranged from $ 5,500 to $ 25,000.

5. Eighteen grants totalling $ 243,039 were awarded for studies focusing on ways of reducing pesticide input into the environment and enhancing the effectiveness of pest management practices.

6. Eleven grants totalling $ 149,600 were allocated for studies focusing on minimizing risks from pesticides to the environment and human health.

7. The Pesticides Advisory Committee is satisfied with the research progress in 1988-89. It recognizes that, with the funds available, the program can be expected to act only as a catalyst in stimulating support by other interested agencies for urgently required research in the broad areas indicated in the Committee's guidelines.

8. The Pesticides Advisory Committee recommends that the Ministry of the Environment continue to support the OPAC research program and OPAC liaison activities insuring financial accountability.

I. OBJECTIVES

The Ministry of the Environment first allocated funds to the Ontario Pesticides Advisory Committee (OPAC) to sponsor pesticide-related research in 1973. Terms of Reference developed by OPAC in 1988-89 to govern the awarding of research grants focused on:

1) Ways of reducing inputs of pesticides into the environment.

2) Minimizing risks from pesticides to the environment and human health.

3) Enhancing the effectiveness of pest management practices.

An announcement inviting research proposals in several specific areas relating to the program objectives is reviewed and revised annually by OPAC in consultation with the Ministry of Environment Research Advisory Committee. In 1988-89, research proposals were invited in twelve specific areas relating to the three research objectives (Appendix I).

II. SELECTION PROCEDURE

Notices inviting applications for research support were widely distributed in November, 1987 through January, 1988 to researchers and administrators in Ontario universities, industry, government, and other organizations, with deadlines for receipt of applications being January 29th and June 30, 1988. For the first time, standard OPAC grant application forms were distributed for completion, so that various aspects of a submission could be easily identified.

During the first two weeks in February, members of the Research Subcommittee and selected reviewers appraised the submissions and ranked the proposals in three categories: fund, not fund, reconsider with changes. The reviewers were chosen for their broad knowledge of pesticides and expertise in pest control.

Criteria used in judging the applications included:
i) applicability to research objectives,
ii) scientific quality of the research proposal,
iii) qualifications of the applicant(s).

Six applications were received later in the year and were similarly considered.

Recommendations prepared by the Research Subcommittee were reviewed by the Pesticides Advisory Committee in February. OPAC recommendations were then forwarded to the Ministry of Environment's Research Advisory Committee for confirmation and funding. Funds were made available to most grant recipients by mid April.

III. PROJECTS SUPPORTED

The OPAC research budget in 1988-89 was $ 400,000.

Fifty research proposals totalling $ 949,960 were received. Most (42) were from universities/colleges (Guelph, Queen's, Sault College of Applied Arts and Technology, Ridgetown College of Agricultural Technology, Toronto, Western, Waterloo, and Brock). The remaining applications were from industry or other organizations.

Twenty-nine proposals were supported (Appendix II). Awards averaged $ 13,539 (range $ 5,500 to $ 25,000). Disbursement of research funds by organization is summarized below:

Organization	No. of Grants	$ Total of Grants
University of Guelph	13	215,490
Sault College of Applied Technology	4	46,500
Queen's	1	5,500
University of Western Ontario	2	33,200
Ridgetown College of Agricultural Technology	1	6,000
University of Toronto	3	31,749
University of Ottawa	1	10,000
Other	4	44,200
TOTAL	29	392,639

Results obtained in the various studies are summarized in Appendix III.

Eighteen grants (Appendix III #s 1, 4, 5, 6, 7, 8, 9, 12, 13, 16, 17, 18, 20, 23, 24, 25, 28, 29) totalling $ 243,039 were awarded for studies focusing on ways of reducing pesticide input into the environment and enhancing the effectiveness of pest management practices.

Eleven grants (Appendix III #s 3, 10, 11, 14, 15, 19, 21, 22, 26, 27, 30) totalling $ 149,600 were allocated for studies focusing on minimizing risks from pesticides to the environment and human health.

IV. ACCOUNTABILITY

Direction and progress of the research were monitored by OPAC in several ways. Initially, some applicants were asked to modify their proposals to better meet the research guidelines. In May/June 1988 as part of the OPAC annual Field Trip, some of the researchers receiving financial support were included on the agenda, thus giving OPAC members an opportunity to become acquainted with the cooperating scientists and research in progress. Informal contacts with OPAC members and grant recipients were established and maintained throughout the year.

In January, 1989, OPAC sponsored a two day Seminar where grant recipients presented the results of their research. This meeting was attended by OPAC members and more than 90 colleagues, peers, and guests.

In addition, the recipients were asked to provide OPAC with a summary of progress (Appendix III).

Research reports, manuals, theses etc. published in 1988-89 relating to OPAC sponsored research are listed in Appendix IV.

V. RECOMMENDATIONS

The Pesticides Advisory Committee is satisfied with research progress made in 1988-89. The Committee recognizes that with the funds available, the program can be expected to act only as a catalyst in stimulating support by other interested agencies for urgently required research in the broad areas indicated in the Committee's guidelines.

The Committee recommends:

1) The Ministry of the Environment continue to support this very productive research program directed towards development of pest control programs which will not pose any serious environmental hazard.

2) The Ontario Pesticides Advisory Committee continue to supervise this program following the guidelines which have been developed. With its broad expertise, strong scientific background and close liaison with the scientific community, OPAC is in the unique position of being able to define research priorities and to ensure that excellent value is received for money spent.

APPENDIX I: ANNOUNCEMENT INVITING APPLICATIONS FOR RESEARCH SUPPORT FROM THE ONTARIO PESTICIDES ADVISORY COMMITTEE

November 1987

The Ontario Ministry of the Environment through the Pesticides Advisory Committee again has funding available for the fiscal year 1988-89 for the support of research relating to the use of pesticides in Ontario.

Research projects should focus on:

1. Ways of reducing inputs of pesticides into the environment.

2. Minimizing risks from pesticides to the environment and human health; and,

3. Enhancing the effectiveness of pest management practices.

Proposals should be designed to yield useful results in a relatively short time, generally in three years or less. Funding is committed an a yearly basis but may be extended on receipt of evidence of satisfactory progress and is conditional on continued availability of funding from the Ministry of Environment.

There are two deadlines for the submission of proposals for funding in 1988-89: January 29, 1988 and June 30, 1988. It is anticipated that most of the funds available will be distributed in response to proposals received in January. Normally, successful applicants will be notified early in April and in early October (January and June applicants respectively).

Applications should be made on forms provided by the Pesticide Advisory Committee and submitted to:

The Executive Secretary
Ontario Pesticides Advisory Committee
Ministry of the Environment
135 St. Clair Avenue West, Suite 100
Toronto, Ontario M4V 1P5

Successful applicants are expected to provide a written abstract prior to, and an oral progress report at the Committee's annual research seminar in January each year, and to submit a summary progress report by the end of February.

Final reports acceptable to the Committee will be required at the termination of projects. Copies of publications arising from projects must also be submitted. A financial report may be required at the discretion of the Committee.

Although it is not intended to constrain the scope of proposals, the following list is included to indicate some of the areas of special interest. This is not a priority list.

1. Persistence, degradation and biological and/or human significance of pesticide residues in soil, air, water and food.

2. Potential for deleterious contamination by pesticides of ground and surface waters and methods of minimizing undesirable contamination.

3. Determination of exposure of agricultural, horticultural and forestry workers, licensed applicators, and the public to various types of pesticide applications and of safe re-entry procedures following pesticide applications in buildings and out-of-doors.

4. Assessment of the effectiveness of protective equipment and the development of improved protective equipment.

5. Criteria of need for and the development of buffer zones for aerial and ground application of pesticides.

6. Investigation of pesticides in the urban environment with respect to use patterns, application methods and impacts on human health and environment.

7. Development of non-chemical methods of pest control including biological and cultural methods.

8. Development of improved integration of biological, chemical, cultural and other pest control practices to achieve greater efficacy and elimination of unnecessary pesticide applications.

9. Development of more efficient, effective and cost-effective techniques of pesticide application and spray timing.

10. Development of pest and weather monitoring techniques and methods for effective utilization of information from monitoring.

11. Economics of pest control, including determination of economic thresholds and estimates of crop losses.

12. Identification of efficient, effective and environmentally acceptable pesticides or pest control methods for use in structures or for protection of stored products.

APPLICATION PROCEDURE

Research proposals should be submitted to:

Dr. K. A. Howard
Chairman
Pesticides Advisory Committee
Ministry of the Environment
Suite 100, 135 St. Clair Avenue West
Toronto, Ontario M4V 1P5

Applications should be received by January 23, 1987, and should include the following:

1. Title of project.

2. Name, address and affiliation of applicant(s).

3. Summary of proposal

4. Discussion of problem.

5. Statement of objective(s).

6. Plan for program.

7. Facilities available.

8. Budget - categorize costs as: Personnel - full/time and part/time, Equipment, Supplies, Overhead Costs, Other.

9. Curriculum vitae on principal investigator(s), (if not already on file with OPAC).

APPENDIX II: RESEARCH PROJECTS SUPPORTED BT THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1988-89

Project #	APPLICANT(S)	AFFILIATION	PROJECT TITLE	$ AMOUNT GRANTED
1.	ALEX, J.F. HALL, J.C.	U. of Guelph	Reduction in herbicide use through cultural control of weeds in lawns.	13,500
2.	ALLEN, W.R. TRIMBLE, R.M. PREE, D.S.	Vineland	Development of a serological assay for the detection of eggs and larvae of the parasite Pholetesor originis in spotted tentiform leafminer.	0
3.	BARBER, K.N.	Sault College	Determination of the sensitivity to Bacillus thuringiensis of non-target larval lepidoptera potentially serving as food for young grouse chicks.	10,800
4.	BROWN, R.H.	RCAT	Assessment of reduced amounts of herbicides applied more frequently and/or in combination to orchard crops to reduce pesticide loading and improve control strategies.	6,000
5.	BOLAND, G.J.	U. of Guelph	Biological control of Sclerotinia sclerotiorum in white bean and canola.	16,500
6.	BURPEE, L.L.	U. of Guelph	Studies on the relationship between the efficacy of inoculum of Sclerotinia sclerotiorum and mortality of dandelions in turfgrass swards.	15,000
7.	CUNNINGHAM, J.C. KAUPP, W.J.	Sault College	Development of gypsy moth nuclear polyhedrosis virus as a microbial insecticide for use	13,800

in Canada.

NO.	APPLICANT(S)	AFFILIATION	PROJECT TITLE	$ AMOUNT GRANTED
8.	ELLIS, C.R.	U. of Guelph	Development of methods to monitor winter survival and larval establishment of corn rootworms.	21,800
9.	FITZ-JAMES, P.	U. of Western Ontario	A culture protecting corn from western corn root worm damage: studies of minimal protective dose, soil survival, sensitivity to pesticides, and mode of action.	16,000
10.	FRANK, R.	OMAF U. of Guelph	Studies on dispersion of oxyfluorfen and oxidiazon and dislodgeable residues of pyrazophos and oxyfluorfen.	6,500
11.	GAYNOR, J.D.	Harrow Research Station	Atrazine and metolachlor persistence and runoff losses from three tillage systems in corn.	18,800
12.	HARMSEN, R.	Queen's University	Mite IPM in apple orchards: Development of a protocol utilizing pyrethroid resistance and a new synthetic pyrethroid.	5,500
13.	HASTINGS, J.B.	Coopers Mills	Using phermones as a mating disruption method in order to reduce subsequent larval damage by the grape berry moth.	9,400
14.	HOFSTRA, G. FLETCHER, R.A.	U. of Guelph	Measurement of phytotoxicity of sub-lethal glyphosate deposits on selected woody weed species.	11,500

NO.	APPLICANT(S)	AFFILIATION	PROJECT TITLE	$ AMOUNT GRANTED
15.	KAUSHIK, N.K.	U. of Guelph	Effects of microencapsulated and EC permethrin, and a new generation synthetic pyrethroid San 811-I, on stream invertebrates.	13,500
16.	KEVAN, P.G. EISKOWITCH, D. LACHANCE, M.A.	U. of Guelph U. of Western Ontario	Using yeasts to suppress seed production in field milkweed.	15,000
17.	McLEOD, D.G.R. TOMLIN, A.D. TOLMAN, J.H. WHISTLECRAFT, J.W.	U. of Western Ontario	Assessment of the potential of _Aleochara bilineata_ for the control of root maggots in the home garden.	17,200
18.	NEALIS, V.G. SMITH, S.M.	Sault College U. of Waterloo	Improving the biological control potential for gypsy moth in Ontario through the introduction of new strains of the parasitoid _Cotesia melanoscela_.	12,500
19.	RIPLEY, B.D. RITCEY, G.	OMAF U. of Guelph	Comparative behaviour of pesticides with respect to worker safety. 1. Re-entry intervals 2. Dislodgeable residues.	9,500
20.	SANDERS, C.J.	Sault College	Control of spruce budworm by mating disruption: Effects of different phermone blends.	9,400

NO.	APPLICANT(S)	AFFILIATION	PROJECT TITLE	$ AMOUNT GRANTED
21.	STEPHENSON, G.R.	U. of Guelph	Further studies on dislodgeable residues of 2,4-D in turfgrass situations.	24,000
22.	STEPHENSON, G.R.	U. of Guelph	Fate of sulfonyl urea herbicides in Ontario soils.	12,000
23.	SURGEONER, G.A.	U. of Guelph	Reversing insecticide resistance in the house fly by a sanitation and susceptible fly release program.	17,990
24.	SUTTON, J.C.	U. of Guelph	Biological control of grey mold in strawberries.	17,500
25.	SWANTON, C.J. MICHAELS, T.E.	U. of Guelph	Integrated weed management for white beans.	12,200
26.	STOKES,P.M. WHELPDALE, D.	U. of Toronto	Data analysis and interpretation of pesticide concentrations in lichens from 45 sites in Ontario (the Upper Great Lakes basin).	8,000

NO.	APPLICANT(S)	AFFILIATION	PROJECT TITLE	$ AMOUNT GRANTED
27.	WEINBERGER, P.	U. of Ottawa	A new factor to consider in pesticide fate-transport studies.	10,000
28.	GRACE, J.K.	U. of Toronto	Evaluation of the use of termite attractants to synergize soil pesticide applications in structural pest control.	14,700
29.	SMITH, S.M.	U. of Toronto	Potential for using egg parasitoids such as Trichogramma against epidemic populations of forest tent caterpiller.	9,049
30.	HALL, J.C.	U. of Guelph	Development of enzyme immunoassays and radio immunoassays using polyclonal and monoclonal antibodies for the detection of herbicidal residues.	25,000

APPENDIX III: SUMMARY PROGRESS REPORTS, 1988-89

1. ALEX, J.F. and J.C. HALL - Reduction in herbicide use through cultural control of weeds in lawns.

During the next 15 years, the Ontario Government has the declared objective of reducing, by 50%, pesticide use throughout the province. An appreciable proportion of phenoxyalkanoic herbicide use in Ontario is applied to turf for broadleaf weed control. Furthermore, there has been much public concern about health risks involved with use of phenoxyalkanoic herbicides, particularly 2,4-D. Therefore, any program aimed at reducing the need for the use of these herbicides would appreciably reduce overall phenoxyalkanoic herbicide consumption within the province and reduce potential health risks that may be associated with use of these herbicides.

Herbicides are perceived by most homeowners and commercial turf growers as the main, and often the only solution for their broadleaf weed problems. However, many weed infestations in turfgrass swards are caused by improper seedbed preparation, incorrect selection of a turfgrass species and varieties suitable for the growing conditions, and poor fertility and watering regimes. To reduce consumption of phenoxyalkanoic herbicides, homeowners and commercial turfgrass growers in Ontario need information about the various cultural practices that will reduce weed infestations in turf.

There is a considerable amount of literature on the effect of cutting, fertilizing, species and variety selection, as well as irrigation, on turfgrass development. However, comparatively little has been written on the subsequent effects of these treatments on the ability of turfgrass to compete with weeds.

Experiments have been designed to determine the effects of turfgrass species and cultivar types, fertility regimes, time of seeding and irrigation regimes on turfgrass competitiveness against various broadleaf weeds. Plots were seeded in September of 1988 at the Ridgetown Agriculture College in cooperation with Mr. R. Brown (OMAF). The experiment will be repeated at the Cambridge Research Farm in May 1989. The experimental design is outlined below:

TURFGRASS SPECIES (4): K. bluegrass, perennial ryegrass, tall fescue, fine leaf fescue

CULTIVARS PER SPECIES TYPE (6):
-K. bluegrass: touchdown, america, banff, nassau, baron, haga
-Tall fescue: rebel II, mustang, hounddog, tribute
-Fine leaf fescue: tournament, victory, biljart, spartan, agram, fortress

-Perennial ryegrass: yorktown II, fiesta II, gator, palmer, repell, blazer

FERTILITY REGIMES (4):
- Regime #1: no fertilizer
- Regime #2: 0.5 lb N May, 0.5 lb N August, 1 lb N November
- Regime #3: 1 lb N May, 1 lb N September
- Regime #4: 1 lb N June, 1 lb N November

TIMES OF SEEDING (2):
-Fall seeding at Ridgetown; September 1988
-Spring seeding at Cambridge; May 1989

IRRIGATION REGIMES (2): The experiment will be repeated twice at Cambridge, one experiment will be irrigated and the other will not be irrigated.

A mixture of broadleaf weed seeds has been sown into one half of the plot area of each treatment, allowing us to determine the effect of each of the factors on weed competitiveness.

Based on this research, we expect to establish a data base on the competitiveness of different cultivars and species of turfgrass. Once we have established this data base, we will be able to provide recommendations on the most competitive turfgrass varieties, thereby reducing or eliminating the growers reliance on chemical weed control.

2. <u>ALLEN, W.R.</u>, R.M. TRIMBLE and D.S. PREE - Development of a serological assay for the detection of eggs and larvae of the parasite <u>Pholetesor</u> <u>originis</u> Weed in the spotted tentiform leafminer.

The researchers withdrew this proposal, as test results from Queen's University, key to implementing this research, have been delayed.

3. BARBER, K.N. - Determination of the sensitivity to Bacillus thuringiensis of non-target larval Ledpidoptera potentially serving as food for young grouse chicks.

The lepidopterous fauna feeding on Vaccinium angustifolium has become a concern as a non-target component of a managed forest ecosystem. The primary evidence and documentation has been provided by researchers at the University of Toronto, Faculty of Forestry as part of an on-going, long-term study of the bionomics of spruce grouse. Their unpublished data indicate a strong, negative correlation between caterpillar availability and young chick mortality. Growth and survivorship of young chicks were depressed on sites sprayed with Bacillus thuringiensis kurstaki (B.t.) compared with previous years and control sites.

The main objective of the current research reported here is to provide a finer discrimination of the Lepidoptera components available to foraging spruce grouse chicks during their flightless period. This was approached through a rearing program which is designed to provide identification of adults and initiation of laboratory cultures for bioassay trials.

Sampling was conducted on three occasions, June 1988 on 20-year old plantations of jack pine south of Gogama, Ontario. Sweep net sampling was restricted to Vaccinium angustifolium because this plant overwhelmingly dominates the ground cover. Larvae were transported to Sault Ste. Marie and reared on fresh Vaccinium foliage or artificial diet at 20-21° C.

Leafrollers and leaftiers (~ 12 species of Tortricidae, 1 species of Gelechiidae) were collected and reared. These were not efficiently sampled with sweep nets and are not likely to be significant in spruce grouse chicks' diet as the larvae are concealed from view. About 5 sawfly species were collected but are not expected to be susceptible to B.t.

Table 1 summarizes the collections of externally feeding Lepidoptera only. The noctuids (23 species) and geometrids (9 species) represent a combined total exceeding 99% of all externally feeding caterpillars. Also evident is the reversal of the relative proportions of these two major groups. Geometrids comprise the bulk of the caterpillars in early June (2-7), but by the end of June (26-28) the noctuids have replaced the geometrids as the major component.

TABLE 1. Lepidoptera feeding externally on V. angustifolium

	Estimated No. of Species	% of June Collections 2-7	15-18	26-28	n
Noctuidae	23	16.6	54.9	82.7	1604
Geometridae	9	83.4	44.9	16.6	1219
Others*	3	-	0.1	0.7	8
n		499	1467	865	2831

* Sphingidae(?), Pieridae, Lymantriidae (5,2,1 specimens).

Table 2 indicates that only three species of geometrid comprise more than 99% of all geometrids on all collection dates. Both species of Itame are known to feed on Vaccinium with I.a.orientis perhaps exclusively. Both overwinter as diapaused eggs and we now have hundreds to thousands of eggs in cold storage. These will await the next field season since it is expected that the larvae will require fresh foliage to complete their development. Eulithis has been previously recorded from Vaccinium while most other species are general feeders.

TABLE 2. Composition of Geometridae feeding on V. angustifolium

	% of June Collections			n
Estimated No. of Species	2-7	15-18	26-28	
Itame brunneata	73.1	60.8	47.2	773
I. andersoni orientis	21.2	31.7	41.0	356
Eulithis explanata	5.0	6.5	3.5	69
Subtotal	99.3	99.1	91.7	1198
Others (~6 species)	0.7	0.9	8.3	21
n	416	659	144	1219

In contrast, Table 3 indicates that eight species comprise over 90% of all noctuids. This is evident for at least the two later dates when the noctuids had become well established.

TABLE 3. Composition of Noctuidae feeding on V. angustifolium

	% of June Collections			n
Estimated No. of species	2-7	15-18	26-28	
Orthosia evicta	2.4	44.5	52.7	738
Xylena thoracica	14.5	17.1	18.7	284
Lithophane spp.*	-	10.8	6.7	135
Apharetra purpurea	24.1	10.9	2.5	126
Syngrapha spp.**	36.1	5.8	2.7	96
Oligia illocata	-	2.9	1.8	36
Xyle./Olig./Lith.***	1.2	3.8	7.1	83
Subtotal	78.3	95.9	92.3	1529
Others (~15 species)	21.7	4.1	7.7	75
n	83	806	715	1604

* L. tepida: L. thaxteri (?) at ratio of ca. 5:1.
** S. epigaea: S. altera at ratio of ca. 5:2.
*** confused larvae of Xylena, Oligia, and/or Lithophane spp.

We have nearly 300 pupae of Orthosia in diapause and expect successful rearing attempts with this species on artificial diet. Xylena (72 adults) and the two species of Lithophane (32 and 6 adults) are overwintering in the adult stage and are also expected to be successfully reared on

artificial diet. Apharetra and Syngrapha spp. may require fresh foliage while Oligia can be reared on artificial diet. The eggs which we obtained from this latter group of four species may not be viable. Apharetra (possibly exclusively), Syngrapha epigaea, and three others (two possibly exclusively) are known to feed on Vaccinium.

There is some correspondence between caterpillars found in grouse chick crops and those from the sweep net samples of V. angustifolium. Examination of the crop contents of 15 spruce grouse chicks collected in late June to early July of 1982 and 1985 found that about 11 species were common to both surveys. Of all caterpillars (n=77) in the crops, 42% were Geometridae while 40% were Noctuidae. I. brunneata accounted for 56% of all geometrids (N=32) while Apharetra, Syngrapha, and Orthosia combined to account for 58% of all noctuids (n=31). The presence of Apharetra purpurea, Chrysanympha formosa (a noctuid), and Croesia curvalana (a tortricid) suggests that these chicks foraged in or near blueberry. These three species are currently known to feed only on Vaccinium (at least in Ontario for C. formosa).

Laboratory bioassays will be attempted with the major species using B.t. in the following year to determine relative susceptibility. This information will provide a better means to assess the risk to each of exposure to aerial applications of B.t. These trials require the successful establishment of laboratory cultures. Requirements for diapause and fresh foliage will combine to restrict the scope of the bioassay program to about two species of geometrids and four of noctuids. The identities of the caterpillars provides the potential to collect adults in the field and obtain eggs firsthand and free of parasites. Parasitism and other mortality factors claimed 62% and 35% of all noctuid and geometrid larvae, respectively.

4. BROWN R.H. **Assessment of reduced amounts of herbicides applied more frequently or in combination to orchard crops to reduce pesticide loading and improve control strategies.**

Herbicide treatments were applied for the second consecutive year to the same plots in established apples (variety, Empire), sour cherries (variety, Montmorency), and peaches (variety, HW240) in an orchard near Blenheim owned by Delhaven Orchards (Hector Delanghe). The original objective of the trials was to determine if lower recommended rates of registered herbicides or combinations of herbicides applied twice in a season would result in longer, better weed control at a reduced chemical loading with less cost. Another objective was to test some new chemistry to determine the effect on weed control and the crop. By applying the herbicides to the same plots in two consecutive years it allows one to observe the collective effects of such a practice which in fact simulates what a grower would do commercially.

The main weed species were dandelions, bindweed, quackgrass, Canada thistle, pigweed, lamb's quarters, velvetleaf, eastern black nightshade, barnyard grass, old witch grass and green foxtail.

Glyphosate was applied to all plots at 1.07 kg/ha on June 1, 1988. Treatments were first applied to the plots on June 15 (200 L/ha, 240 kPa). Repeated applications were applied on August 12.

The most effective treatments in the June 29 assessments included combinations of paraquat + EXP 4293, paraquat + oxidiazon, glyphosate + simazine, terbacil and double applications of combinations of ethalfluralin + metribuzin, metolachlor + simazine or metolachlor + metribuzin. The Aug. 30th assessments indicated terbacil to be the best treatment followed by two applications of ethalfuralin + metribuzin, metolachlor + metribuzin, dalapon + simazine, metolachlor + simazine, linuron + oil and glyphosate + simazine in the apple orchard.

In sour cherries, terbacil alone or in combination with paraquat or glyphosate or the graminicides (TF1195, DPX Y6202-31, sethoxydim) looked most promising.

In peaches, terbacil applied twice was most effective. Other promising treatments included linuron, sethoxydim + Assist, glyphosate + linuron (early weed control), paraquat + EXP 4293 (early), and paraquat + oxidiazon (early).

A second very dry, hot year challenged the treatments and their ability to maintain weed control although this orchard was irrigated thoroughly on several occasions.

5. BOLAND, G.J. and G.D. INGLIS - **Biological control of Sclerotinia sclerotiorum in white bean and canola.**

The objectives of these investigations were to evaluate the potential of using selected isolates of nonpathogenic fungi as biological control antagonists for white mold of white bean and canola. The disease cycle of the causal agent, Sclerotinia sclerotiorum, involves the preliminary colonization of senescing and/or dead plant tissues before plant infection can occur. The most common type of such tissues in bean and canola crops during the growing season is flower petals that become lodged throughout the crop after flowering has finished. Therefore, epidemics of white mold occur after the crop flowers. However, a variety of naturally-occurring nonpathogenic fungi also can colonize senescent and/or dead tissues and thereby prevent S. sclerotiorum from becoming established. Organisms that interfere with colonization of the flowers by the pathogen would be expected to reduce disease incidence and/or severity.

Saprophytic fungi and S. sclerotiorum were isolated from flowers at four stages of development in white bean and canola during 1987-88 and cultured on agar media. Sclerotinia sclerotiorum was recovered at very low frequencies whereas more than 65% of the flowers were colonized by isolates of Alternaria and Cladosporium. In addition, S. sclerotiorum was normally found only after flower petals had matured, fallen from the inflorescence, and lodged onto plant surfaces. These results indicate that S. sclerotiorum is not a common inhabitant of flower tissues, especially in the early stages of flower development, and that the encouragement and/or introduction of antagonistic fungi may be a promising approach to management of diseases caused by this pathogen.

A number of methods were developed for evaluating fungi isolated from bean and canola flowers for potential as biological control antagonists. Four hundred and fourteen fungal isolates from 17 genera were evaluated in laboratory conditions using an agar co-maceration technique. Thirty-one of these isolates completely prevented white mold. Subsequent evaluations were conducted in growth room and greenhouse conditions using co-inoculation techniques that were considered to be more strict, and more representative of field conditions. Evaluation trials were conducted on bean seedlings and on flowering bean and canola plants in order to identify the seven most effective isolates at reducing the incidence and severity of white mold. Preliminary field trials in 1987 were not completed because warm, dry weather conditions prevented disease from developing.

In 1988, five field experiments were established at the Arkell Research Station, Ontario. Sequential plantings of the bean cultivar Strike were sown at one week intervals in order to increase the probability of disease occurrence. Antagonist treatments consisted of applications of spore suspensions and/or mycelial homogenates of selected antagonists. Additional treatments included the fungicide benomyl and a control

treatment of distilled water. The number of lesions per plot and final disease incidence were evaluated for each treatment. Additional treatments were included in some experiments to determine the potential for combined treatments of tolerant fungal antagonists and benomyl at normal and reduced rates of application.

In the first field experiment, all of the antagonists resulted in decreased disease incidence but only isolates of Cladosporium, Epicoccum, and Alternaria significantly reduced disease incidence at harvest from 20.0% in the untreated control to 3.0, 4.9, and 6.2% respectively. Plots treated with fungicide alone had 7.6% diseased plants at harvest and were not significantly different from the best antagonist treatments. Combined treatments of antagonists and benomyl were not included in this experiment. Experimental error was large in all of the field experiments in 1988 due to considerable spatial variation in the distribution of disease within the plots.

In four additional field trials, a variety of fungal antagonists were evaluated alone and, for one isolate of Alternaria, in combination with benomyl at normal and one-half of the recommended rates of application. None of the antagonist treatments resulted in a significant suppression of disease incidence at harvest when sprayed alone. However, all treatments that contained benomyl significantly reduced disease incidence compared to the untreated control. Treatments of benomyl at both rates of application that also contained the antagonist Alternaria appeared, in some instances, to enhance reduction of disease incidence. However, this enhancement of disease reduction was variable and in only one of the trials was significantly less than treatment with the corresponding rate of fungicide alone.

In a separate field trial at Arkell in 1988, applications of foliar nutrients to flowering bean plants were evaluated as a method to stimulate the growth of naturally-occurring antagonistic fungi, and thereby enhance naturally-occurring biological control. Two foliar sprays of dextrose, methyl cellulose, urea, ammonium sulfate, ammonium chloride, calcium carbonate, a surfactant, water, benomyl, and one isolate of Alternaria were applied at one week intervals during the crop flowering period. As in the previous trials, the spatial distribution of disease in the field plot was highly variable and resulted in a large experimental error. The fungicide treatment of benomyl was the only treatment that resulted in a significant decrease in disease incidence. Treatments of Alternaria, ammonium sulfate and ammonium chloride reduced disease incidence to less than one-half of the untreated control but were not significantly different.

Results from these experiments indicate that some of the fungal isolates that have been selected to date have potential for biological control of S. sclerotiorum. However, the efficacy of these isolates is variable and other factors, such as environment, may be restricting their potential.

In addition, combination treatments of tolerant antagonists and reduced rules of fungicides may have some potential for enhanced control of white mold.

A number of the most promising isolates that have been selected to date are also being evaluated for efficacy on other crops and diseases. In a cooperative research program with Agriculture Canada, British Columbia, isolates are being evaluated for potential to control Sclerotinia and Botrytis on Kiwi fruit. Preliminary results appear promising and these studies have been expanded to Kiwi fruit in New Zealand. In addition, studies have been initiated on the potential of these isolates to control Botrytis in greenhouse crops such as cucumber and chrysanthemum.

6a. RIDDLE, G.E. and L.L BURPEE,- Relationship between efficacy of inoculum of Sclerotinia spp. and mortality of dandelions in turfgrass swards.

Sixty isolates of Sclerotinia sclerotiorum and six isolates of S. minor were evaluated for virulence to the common dandelion (Taraxacum officionale Weber) in controlled environment. Isolates were categorized as 'weakly virulent', 'moderately virulent', or 'highly virulent' after incubation for 72 hours at 23^{o} C and 100% RH on detached leaves from 8-week-old dandelions. Isolates obtained from the same host species, but from different localities, were not equally virulent.

Five isolates of Sclerotinia representing a wide range of virulence (as defined in detached leaf tests) were used in tests designed to assess the relationship between inoculum concentration and disease intensity on dandelion. A weakly virulent isolate (R72) of S. sclerotiorum did not cause detectable leaf collapse of 8-week-old dandelion plants even when a high concentration of inoculum (16 propagules/plant) was applied. In contrast, a highly virulent isolate (R56) of S. sclerotiorum caused severe defoliation of 8-week-old dandelions when applied at a rate of 1 propagule/plant. With moderately virulent isolates, the relationship between virulence and disease intensity on dandelion was less distinct when the application rate of inoculum was increased.

In 1987, four applications of perennial ryegrass seed (100 g/m^2) infested with isolate R30 of S. sclerotiorum, followed by six applications at the same rate in 1988 resulted in a significant reduction (P=0.05) in the total number of dandelion flowers in a turfgrass sward and a reduction in the number of flowers produced/plant (Table 1). An 80.7% reduction in number of dandelions was observed in turfgrass swards treated with inoculum of isolate R30. Population of dandelions in untreated swards increased 22.5% during the same period of time (Figure 1). Inoculum (100 g/m^2) of isolate R30 of S. sclerotiorum applied simultaneously with dandelion seed (25 g/m^2) onto a sward of Kentucky bluegrass reduced the establishment of dandelion seedlings by 85.5%. Significant correlations

were detected in 1987 and 1988 between virulence of isolates of Sclerotinia (as defined in detached leaf tests) and reduction in the intensity of dandelion foliage or numbers of dandelion plants in swards of Kentucky bluegrass. Twenty-three isolates of S. sclerotiorum and 4 isolates of S. minor were applied to turfgrass swards during various field experiments in 1986, 1987, and 1988. No pathogenicity of Sclerotinia spp. was observed on Kentucky bluegrass, creeping bentgrass, or annual bluegrass, even in swards receiving inoculum applications of 100 g/m^2 at 3-week intervals.

Results of this study indicate that isolates of S. sclerotiorum and S. minor have the potential to act as successful mycoherbicides for control of dandelions in turfgrass swards.

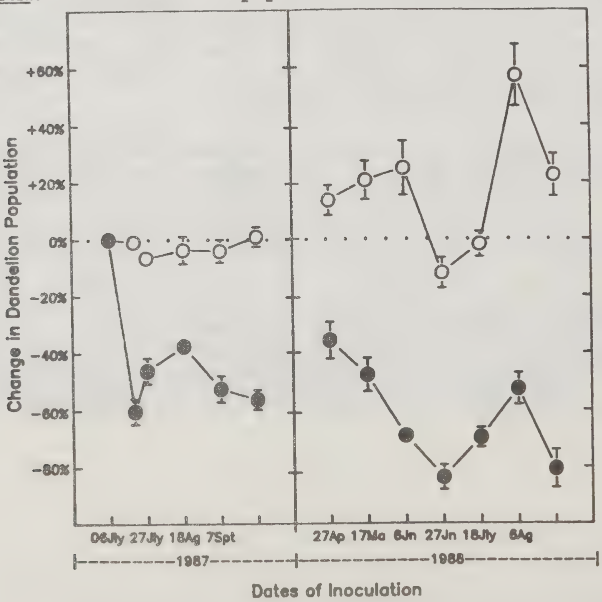
Table 1. Effect of repeated applications of inoculum of Sclerotinia sclerotiorum on production of dandelion flowers in a turfgrass sward

Treatment[a]	# of flowers/plot[b]	# of flowers/plant[b]
Isolate R30	8.5 + 6.4	0.37 + 0.08
No inoculum	74.0 +28.5	1.64 + 0.10

[a] Forty grams of autoclaved perennial ryegrass infested with S. sclerotiorum (isolate R30) was applied to 40x100 cm subplots containing dandelions and a mixture of turfgrass species on 06 July, 27 July, 18 August, 10 September 1987, and 27 April, 17 May, 06 June, 19 July, 09 August 1988.

[b] Values represent means +/- 95% confidence intervals.

Figure. 1. Effect of repeated applications of inoculum of Sclerotinia sclerotiorum on an infestation of dandelions in a turfgrass sward. Forty grams of autoclaved perennial ryegrass infested with S. sclerotiorum isolate R30 was applied to 40x100 cm subplots. ● = dandelion population in turfgrass plots that received repeated applications of inoculum of S. sclerotiorum. o = dandelion population in untreated plots.



6b. BURPEE, L.L., I.A. VELIKY, and A.E. MUELLER - **Preliminary studies on the efficacy of formulations of a bioherbicide for control of dandelions in turfgrass sward.**

Studies were conducted to assess the efficacy of formulations of bioherbicide R56 on 8-week-old dandelions in controlled environment. Formulations were prepared at the Ottawa Laboratories of Philom Bios Inc. by growing isolate R56 of Sclerotinia sclerotiorum in liquid-culture. Formulations varied with respect to duration of incubation in liquid culture, and to the nature and concentration of inert ingredients added as pre- or post-incubation treatments. Nine formulations were air-dried and shipped to the University of Guelph for evaluations of virulence on dandelions.

Virulence of the formulations was assessed on dandelions cultured from seed in cups of vermiculite for 8 weeks at 23° C in a plant growth room. Leaves of 80 plants (1 plant/cup) were excised 1 cm above the surface of the planting medium, leaving a rosette of petioles in each cup. Three granules (i.e. 3 colony-forming units) of each formulation were placed in the rosette of petioles of 72 plants (8 plants/formulation). The eight remaining plants served as untreated controls. Immediately after inoculation, all plants were misted to run-off with tap water, and then placed in a mist chamber. Plants were incubated in the mist chamber for 96 hr at 23° C and 100% RH, and then removed from the chamber and placed on a bench in a plant growth room for 5 days at 23° C. Viability of the plants was assessed by counting the number of symptomless leaves, >3 cm long, on each plant at 0 days and 5 days after removal from the mist chamber.

Plants treated with formulations 0788-03 and 0788-04 failed to produce new leaves vegetatively (Figure 1), suggesting that these formulations were highly virulent on dandelion. Leaves were produced by all plants treated with the other formulations tested. Viability of the formulations was assessed by placing granules of the formulations on the surface of BASM agar in plastic petri dishes. The rate of colony formation from the granules was not correlated ($r=0.1$) with efficacy of the formulations on dandelion. Results of further tests revealed that applications of formulations, 0788-03 and 0788-04 resulted in significant ($P=0.05$) reduction in viability of dandelions after as little as 24 hr of plant wetness at 23° C (Figure 2). Applications of formulation 0788-04 resulted in a greater percentage of plant mortality than applications of 0788-03 at all durations of plant wetness tested.

Results of these preliminary studies indicate that it is possible to produce granular formulations of bioherbicide R56 that have the potential to kill 8-week-old dandelions at 23° C and 24 hr of plant wetness.

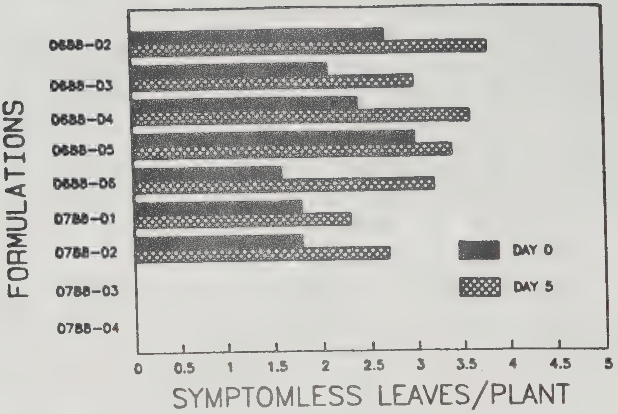


Figure 1. Effect of formulations of bioherbicide R56 on 8-wk-old dandelions in controlled environment. Number of symptomless leaves/plant was determined at 0 days and 5 days after exposure of plants to 100% RH at 23 C for 96 hr.

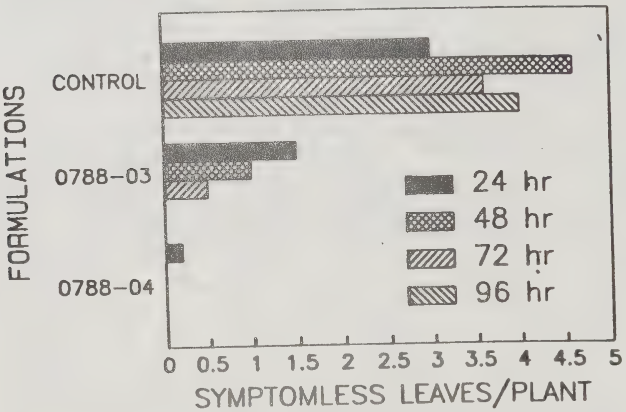


Figure 2. Effect of duration of plant wetness on efficacyof formulations of bioherbicide R56 on 8-wk-old dandelions in controlled environment. Number of symptomless leaves/plant was determined 5 days after exposure of plants to 24, 48, 72, or 96 hr of plant wetness at 23 C.

7. CUNNINGHAM, J.C. and W.J. KAUPP - Development of gypsy moth nuclear polyhedrosis virus as a microbial insecticide for use in Canada.

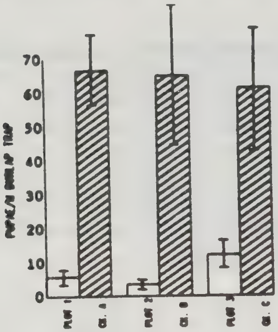
The objectives of this project are to develop gypsy moth, Lymantria dispar (L.), nuclear polyhedrosis virus (NPV) as a viable option for management of this pest and to study the epizootiology of both naturally occurring and artificially disseminated NPV in populations of gypsy moth. A gypsy moth NPV product was registered in the USA by the USDA Forest Service under the name Gypchek in 1978; the same strain of NPV is produced in gypsy moth larvae at the Forest Pest Management Institute (FPMI) and the Canadian product has been called Disparvirus. A Canadian registration petition for Disparvirus is currently being prepared.

A detailed assessment was made of the impact of an application of Disparvirus on gypsy moth populations in 1988. Three plots to be treated were selected in Lindsay District (combined area 64.0 ha), with pre-spray egg mass densities of 2, 470, 2330, and 8500 egg masses/ha. These were paired with three check plots having egg mass densities of 1430, 1750 and 6670 per ha. A Cessna Ag-truck fitted with four Micronair AU 4000 atomizers was used to spray the plots with a double application of 1.25 x 10^{12} polyhedral inclusion bodies (PIB)/ha in 10L/ha (the harvest of NPV from about 1000 heavily infected or dead gypsy moth larvae yields 2.5 x 10^{12} PIB). Larvae were mainly in the first instar at the time of spraying. The applications were 3 days apart. The tank mix contained 25% (v/v) molasses and 6% (w/v) Orzan LS as a sunscreening agent.

Epizootiological studies involved individual microscopic examination of almost 10,000 larvae collected pre-spray and at weekly intervals post-spray from treated and check plots. In the treated plots, peaks of NPV infection, recorded 12 to 19 days post-spray, reached 60.5, 84.9 and 48.7% of larvae infected; secondary peaks of 78.2, 65.2 and 37.1 were recorded at the onset of pupation 40 to 47 days post-spray. In the check plots, levels of naturally occurring NPV remained low until late in the season when they increased rapidly, reaching levels of 27.1, 56.6 and 42.5% of larvae infected.

Larval and then pupal counts were made at weekly intervals in all plots. Burlap traps were used to enumerate larger larvae and pupae. The counts of pupae per metre of burlap trap were 5.8, 3.5 and 12.0 for the treated plots compared to 66.4, 64.8 and 60.9 in corresponding check plots Fig. 1). Defoliation estimates on red oak, Quercus rubra L., are shown in Fig. 2. Plots 2 and 3, both with 14% defoliation, were significantly different from corresponding check plots which had 82 and 90% defoliation, respectively. However, there was no significant difference between Plot 1 with 46% defoliation and Check A with 31% defoliation. The heavier defoliation in Plot 1 can be attributed to the presence of oak leaf shredder, Bruce spanworm and forest tent caterpillar as well as gypsy moth. Reductions in egg mass density due to the NPV treatment, corrected

for naturally occurring population changes in corresponding check plots, were calculated to be 84, 85 and 92% for the three sprayed plots (Table 1).



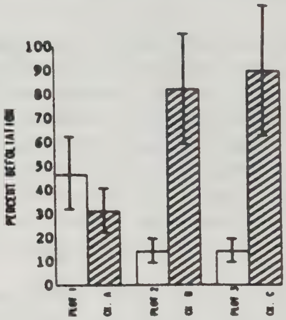


Table 1. Pre-spray and post-spray gypsy moth egg mass (E.M.) counts in plots treated with Disparvirus and treated check plots and the population reduction due to treatment, using a modified Abbott's formula.

	Pre-spray E.M. count/ha	Post-spray E.M. count/ha	% Population reduction due to treatment
Plot 1	2470 ± 573[a*]	600 ± 221[cd]	84
Check A	1430 ± 210[ab]	2230 ± 543[a]	-
Plot 2	2330 ± 410[a]	170 ± 40[d]	85
Check B	1750 ± 183[a]	870 ± 219[bc]	-
Plot 3	8500 ± 2738[e]	210 ± 71[d]	92
Check C	6670 ± 1554[e]	1980 ± 605[a]	-

*Numbers followed by the same letter are not significantly different ($p < 0.05$ two sample t-test).

Results of this trial are considered to be highly successful and will be incorporated in the Disparvirus registration petition. Further trials are required to establish NPV as an economical alternative to Bacillus thuringiensis which is the only microbial agent currently used for gypsy moth control in Canada. In 1989, it is planned to test a lower dosage of NPV (double application of 5X1011 PIB/ha) and a lower application volume (2.5 L/ha). FPMI is negotiating with a French company, Calliope, which is interested in marketing a gypsy moth NPV product in Ontario. A commercial source of NPV is vital for it to become a viable pest management tool.

8. ELLIS, C.R., J.F.STOEWEN, and P.J. MACDONALD- **Development of methods to monitor winter survival and larval establishment of corn rootworms.**

About a million acres of field corn are treated each year in Ontario for rootworms although the treatments pay on only about one-quarter of these fields. Attempts to predict which fields require treatment have been based on monitoring rootworm adults in the fields when they are laying eggs the previous fall. However, due to differences in winter survival and other factors, there is poor correlation between numbers of ovipositing adults and subsequent damage. In this paper we report the completion of a project on the feasibility of monitoring winter survival of eggs in corn fields.

Approximately 11,000 eggs obtained in the laboratory were buried in mesh bags over the winter of 1988. The viability of these eggs was compared to that of resident eggs in two fields with a large natural infestation. In both fields viability of resident eggs was greater than that of eggs in the mesh bags and in one field this difference was significant. We also noted more mold on our eggs used for monitoring than we did on the resident eggs. This poor viability was in spite of our best efforts in producing and handling eggs used for monitoring purposes. Retrieval time in the spring between 15 April and 5 May had no significant effect on viability of the eggs. Overall, greater than 80% of the eggs were recovered. Mean viability was about 20% and viability was significantly higher with eggs buried deeper in the soil. The viability in bags of eggs recovered from four locations in four fields was not significantly different. While the lack of significant differences between locations within a field was encouraging, our method was not able to distinguish between fields in different areas of southwestern Ontario, at least not those with the similar clay soil we tested. Viability of eggs held in bags at a constant cold temperature in the laboratory was comparable to that of eggs buried at 15 cm depth in the fields.

Laboratory investigations showed that low temperatures influenced viability of northern corn rootworm eggs. When held for four weeks, greatest hatch occurred in eggs held at $+1^{o}$ C as compared to eggs held at -5^{o} C. Weekly fluctuations in temperature did not increase mortality. At 20^{o} C, greatest survival occurred at 100% RH with continuous contact moisture. In general, as available moisture increased, percentage hatch increased. No significant differences of hatch in response to moisture were observed between northern and western corn rootworm eggs.

9. FITZ-JAMES, P., S.VAN EVRA and D. LOEWY - A culture protecting corn from western corn root worm damage: studies of minimal protective dose, soil survival, sensitivity to pesticides and mode of action.

This past year, studies on the unusual Bacillus laterosporus culture showing protection of corn from western corn root worm have continued.

Field tests were conducted not only on the inbred corn variety previously shown to be protective (OHIO 43) but also on hybrid corn (Jaques 4200) and sweet corn (Honey and Cream and Seneca Chief). Rows (100 m) of inbred and hybrid corn planted on June 1 were set up as corn only, corn & Diabrotica vergifera (40 eggs per plant at seeding) and corn & eggs & culture sprayed down the planted row. Corn heights were measured weekly; root weights were assessed on three occasions (July 12, July 19 and August 20). Initially, on July 12 and 19, both inbred and hybrid showed considerable root protection from the added culture. The corn plus worm root weights were some 60% reduced, worms (3-4) were found in each root. In 4 culture treated plants examined and weighed the roots were healthy, apparently free of worms and some 50% heavier. This difference in root health and plant size was greatly reduced following 6-8 weeks of drought and heavy rain in the test area. On August 20, although the inbred indicated some culture protection, hybrid stalks and roots showed such extensive development in both control and treated that culture protection, if any, appeared minimal.

The sweet corn, however, showed considerable protection in both root development and plant size. This corn was tested in a plot infested with both inherent and added worms of Diabrotica vergifera. The test culture corn tassels were some 30 cm higher than those of corn NOT treated with B. laterosporus. Both varieties of sweet corn showed this effect. Parts of the plot culture treated in 1987 also showed protection (enhanced growth) of sweet corn.

Greenhouse studies. Root damage by worms and culture protection were assessed on corn plants growing in 6 inch pots (5 plants/group). The plant growth heights recorded in pots with culture added were similar to those recorded previously. Control roots exposed to some 20 worms per pot averaged 33.4 grams while those also receiving 40 mls of sporulated culture per pot averaged 75 grams.

Laboratory studies. The ability of this culture to grow in the presence of commonly used farm chemicals is being tested. Atrazine from 5 to 100 ug/ml of agar showed no effect on the growth and sporulation of the culture. Counter 15G (Cyanamid) completely inhibited the growth of the culture down to about 5 mgs/ml of agar. Since the recommended application is 75 gm/100 meters (7.5 mgs/cm) it is possible the recent use of terbufos explains the disappearance of these cultures from the initial isolate field in Indiana. The work continues on this interesting culture.

10a. FRANK, R., H.E. BRAUN, G. RITCEY and J. STANEK - Determination of dislogeable and removable residues of pyrazophos from crysanthemums.

Residues of pyrazophos were measured on chrysanthemums grown in growth chambers under conditions similar to those in commercial greenhouses. In six separate commercial crops of greenhouse chrysanthemums no evidence of pyrazophos breakdown was observed between the final application and sale of flowers 14 days later.In two experiments pyrazophos disappeared from plants with a half life of 19 and 25 days. On day 0 after allowing the spray to dry, 82% of the residue was removed by washing; at day 35, the amount removed was 43%. Removal by swabbing over the 35 days varied from 4.2% to 7.1%, and was similar to the results found with commercial crops. Swabs (wipings) of two commercial crops dislodged between 2.7% and 4.6% of the residue during the 14 days before sale.

10b. CLEGG, S., FRANK, R., and G. RITCEY - Persistence of oxyflurofen (Goal) in soil, on onions, and potential movement to water.

Oxyfluorfen was applied to onions and soil at 192 g ai/ha or 1250 ml/ha of product in a single application on June 21, 1988. Samples of onions taken at 0, 1, 2, 3, 4, 5, 6, 7 and 14 days after application were examined for residues. Initial residues were 0.19 mg/kg and declined rapidly to non detectable residues (<0.05 mg/kg) by day 4 with a half life residue disappearance of 0.9 days. Soil samples were taken at three depths 0-5 cm, 5-10 cm and 10-15 cm according to the schedule of 0, 10, 30, 50, 99 and 134 days. Analysis of soils at the 0-5 cm depth had initial residues of 3.9 mg/kg which declined to 1.0 mg/kg by day 134 giving a half life disappearance of 86 days. At the 5-10 cm depth residues were initially at 0.92 mg/kg and declined to 0.48 mg/kg by day 134 with a half life disappearance of 125 days. Initial residues at the 10-15 cm depth were 0.41 mg/kg and declined to 0.19 mg/kg with a half life disappearance of 114 days over the same period of 134 days. Water collected from the drains at the corner of the field were sampled and analyzed weekly to monitor potential movement to water systems. No residues of oxyfluorfen were detected.

10c. CLEGG, S., FRANK, R., and G. RITCEY - Oxadiazon (Ronstar) residues on onions and in organic soil.

Oxadiazon was applied to onions and soil at 1.2 kg ai/ha or 3 L/ha of product June 21, 1988. Onions were sampled at days 0, 1, 2, 4, 6, 8, 10, 12 and 14 and residue analysis showed initial residues of 4.3 mg/kg that declined to 0.22 mg/kg by day 14 giving a half life disappearance of approximately 3.1 days. Soil samples were taken at 2 depths: 0-5 cm and 5-15 cm. In the 0-5 depth soils initial residues were 19 mg/kg and declined to 6.8 mg/kg by day 134, whereas initial residues at the 5-15 cm depth were 1.1 mg/kg and declined to 0.27 mg/kg over the same time period. The disappearance half lives for the two depths 0-5 cm and 5-15 cm were 204 days and 134 days, respectively. Residue analysis has not yet been completed on samples picked up by scouts visiting onion fields.

11. GAYNOR, J.D., D.N. UMBENHOWER and A.B. LABAJ - Herbicide export from Brookston clay loam soil under conventional and conservation tillage practices.

Replicated plots for three tillage practices were established on a level plain Brookston clay loam soil. The plots were seeded to corn and atrazine and alachlor were applied preemergence at 1.8 and 2.5 kg/ha, respectively. Overland surface water loss was monitored through a weir and tile discharge monitored manually for each rainfall event and total water loss or discharge calculated for each treatment. Water samples were collected during the hydrograph for determination of herbicide concentration. Herbicide loss for the year was calculated for each treatment by summing the product of volume discharged and herbicide concentration for each event. Soil samples were collected from each treatment from the top 10 cm of soil during the growing season and extracted for herbicide concentration.

Rainfall lost by surface runoff and tile discharge did not differ among the tillage practices in each of the three years the study was conducted. Total losses of rainfall for 1984, 1985 and 1986 were 16.8, 30.1 and 46.0% of rainfall, respectively. Rainfall losses were greater through tile discharge than from surface runoff.

Herbicide concentrations were higher in surface runoff than in tile discharge and losses were greater from the surface than from the tile. The amounts of herbicide lost from the three tillage practices did not differ among treatments. Total triazine losses amounted to 1.3, 1.4 and 7.4% of application for 1984, 1985 and 1986, respectively. Alachlor losses were 0.35, 0.18 and 0.52% of application for the corresponding years.

Herbicide residues were similar among the various tillage practices. Alachlor readily dissipated from the soil with no accumulation of residues present at the end of the growing season. Atrazine dissipated to 10-20% of application by the end of the growing season. There was no evidence of soil accumulation of the de-ethylated atrazine metabolite. Triazine residues appeared to be higher on ridge tops than in the valleys of the ridge tillage practice probably because of lower soil moisture content of the ridges.

12a. CLEMENTS, D.R. and R. HARMSEN - Mite IPM in apple orchards: Development of a protocol utilizing pyrethroid resistance and a new synthetic pyrethroid.

The mite problem in apple orchards has presented a challenge to orchard growers since the advent of intensive pesticide management, because foliage feeding mites are readily able to develop pesticide resistance. Predatory mites are also capable of developing resistance, and represent the ideal solution under ideal conditions. The interaction between pesticides and mites is one important area of study (see report by Li, S. and Harmsen, R.). However, it is also important to understand the interactions within the mite system. Earlier, a model was developed in our lab by M.E.J. Woolhouse and R. Harmsen to describe and predict the population dynamics of the mite system. Presently, we are taking a closer look at the biology of the system, looking particularly at the relationship between phytoseiid and stigmaeid predators. Phytoseiids have received more attention because individually they can consume greater numbers of prey, but since stigmaeids occur in apple orchards just as frequently as phytoseiids, it is important to consider their role in the system. Any future IPM protocol will, in all probability be dependent on an understanding of the roles played by both these predatory taxa.

In the first season of this study (1987), behavioral observations of predator-prey interactions indicated that phytoseiids are better adapted to feeding on active prey than stigmaeids. Because of this, it was postulated that competition between predators for different prey stages of the European red mite (ERM) would be limited; stigmaeids would favour eggs while phytoseiids would favour active forms. We also found that phytoseiids do not attack any stigmaeid stage and that the only phytoseiid stage attacked by stigmaeids is the egg stage.

In 1988 we made a more detailed comparison of prey stage preferences of both phytoseiids and stigmaeids. We compared consumption of every prey stage with consumption of a standard, by presenting adult female predators with equal numbers of each stage and a standard. The standard used for stigmaeids was the ERM egg stage; the ERM larval stage was the standard used for phytoseiids. The consumption of a given stage was expressed as a proportion of the total consumption of that stage and the standard. This was used as an index of prey stage preference. Stigmaeids showed a much higher preference for eggs than phytoseiids, while only phytoseiids were able to eat adult forms (Table 1).

TABLE 1. Mean proportion of ERM prey stage consumed when equal numbers of the prey stage and the standard (stigmaeids=egg; phytoseiids=larva) were presented

	ERM Prey Stage*								
Predator	E	L	QL	P	QP	D	QD	F	M
Stigmaeids	0.50	0.35	0.42	0.35	0.45	0.07	0.29	0.00	0.00
Phytoseiids	0.09	0.50	0.35	0.51	0.34	0.40	0.27	0.05	0.28

*E=egg, L=larva, QL=quiescent larva, P=protonymph, QP=quiescent protonymph, D=deutonymmph, QD=quiescent deutonymph, F=adult female, M=adult male

Stigmaeids clearly favored quiescent stages over active stages while phytoseiids preferred active stages. During their quiescent stages, ERM are immobile and are covered by a shiny transparent integument from which they emerge at the end of the quiescent period. Pooling mean stage and standard consumption for active and quiescent larval stage treatments underlines the differences in the responses of stigmaeids and phytoseiids to active and quiescent prey (Table 2).

TABLE 2. Comparison of mean consumption of active and quiescent stages with mean consumption of the standard (stigmaeids=egg; phytoseiids=larva). N=15, except for mean stage and standard consumption for active larval stage phytoseiid treatments where N=10. Note: stigmaeid treatments lasted 5 days, while phytoseiid treatments lasted 1 day.

	Active Larval Stages		Quiescent Larval Stages	
Predator	Standard	Stage	Standard	Stage
Stigmaeids	9.2a	3.3c	6.3ab	4.3bc
Phytoseiids	6.9ab	5.6ab	10.5a	5.7b

** Within row means followed by a different letter are significantly different (P <0.05) according to Tukey's studentized range test performed on log-transformed values.

Both predators showed a compensatory increase in consumption of the standard when the treatment contained a stage that was not highly preferred. Summarizing from all treatments, phytoseiids consumed 12.9 forms per day which was 5.6 times the rate of 2.3 per day consumed by stigmaeids. However, the stigmaeid oviposition rate was 1.5 per day,

nearly twice the phytoseiid rate. Stigmaeid oviposition was more highly correlated to the eggs consumed than to total consumption indicating that ERM eggs have a greater food value to stigmaeids than other forms.

Further investigations of predator-predator interactions were also made. Given an equal number of phytoseiid and ERM eggs to chose from, the mean proportion of phytoseiid eggs consumed by stigmaeids was 0.38. Oviposition was more highly correlated to ERM egg consumption than phytoseiid egg consumption. It was also shown that stigmaeids seldom consume conspecific eggs and never attack active conspecifics. Likewise, phytoseiids were never found to consume conspecific eggs and we postulate that consumption of active conspecifics is only important when other prey is scarce.

Currently, we are constructing a series of systems models based on the above results and the results of the Li and Harmsen work. These models will lead to the design of an IPM strategy for leafminer and mite control in apple orchards.

12b. HARMSEN, R. and S. LI - The experimental development of synthetic pyrethroid resistance in predatory mites under orchard conditions.

When synthetic pyrethroids are applied as an insecticide to control the tentiform leafminer in apple orchards, they usually cause very high mortality of beneficial mites. This, in turn, will result in outbreaks of phytophagous mites, calling for the use of environmentally dangerous miticides. Predatory mites are the main biological factors controlling harmful mites. If pyrethroid resistant strains of beneficial mites can be bred and used in the field, it will reduce of even eliminate the need to apply miticides in apple orchards. The overall goals of this study are to develop synthetic pyrethroid resistance in beneficial mites (mainly phytoseiids and stigmaeids), and to develop an integrated system of mite management in apple orchards.

An orchard consisting of 150 apple trees at the Smithfield Experimental Farm of Agriculture Canada was used for the project. The trees are Paula red on MM 106 rootstock. The orchard consists of six rows of 25 trees, and was divided into 24 blocks of six or seven trees each for treatment and replicate purposes. The entire orchard was treated with the same fungicides, organophosphorus insecticides and other chemicals as other commercial orchards in a regular spray program except for the absence of miticides and synthetic pyrethroids other than the experimental PP321 (Karate). Three different treatments of the pyrethroid Karate were applied: 6.25g ai/ha (50% recommended dose), 2.5g ai/ha (20% recommended dose) and none. The applications of Karate were made on June 28, July 28 and September 14, 1988. One day before, both two and 14 days after PP321 applications, samples of apple leaves were taken. Each sample consisted of ten leaves taken randomly from each of the 150 trees. All leaves were

examined under the microscope, and arthropod taxa were recorded quantitatively.

There were no predatory mites in the orchard until late July (Table 1.). During August, the populations of beneficial mites increased rapidly, and peaked in September. Predatory mites were strongly suppressed by Karate. There were significantly more predators in the control blocks ($p < 0.05$) after August 26, while no significant difference was found between predator abundances in the two sprayed treatments ($p > 0.05$). The presence of small numbers of predators in sprayed blocks in late September could be an indication of the development of resistance.

Table 1. The abundance of predatory mites (numbers per 500 leaves) at different treatment blocks in the research orchard.

treatment	13/7	27/7	30/7	12/8	26/8	9/9	23/9
control	0	5a	2a	15a	139a*	389a	45a
2.5g ai/ha PP321	0	0a	0a	9a	4b	47b	9b
6.25 g/ha	0	0a	0a	2a	0b	20b	9b

* p = 0.05, Tukey test.

The major phytophagous mite species, European Red Mite (ERM) <u>Panonychus ulmi</u> was not directly affected by PP321 application (Fig. 1). But it was obviously suppressed by predatory mites. Before September, populations in all three treatments were similar. After September, when predators were abundant in control blocks, the numbers of harmful mites in control areas were significantly lower than those in sprayed blocks, while no significant difference was found between the two sprayed treatments.

Even at lower than recommended doses, Karate was very effective in controlling tentiform leafminer in the apple orchard (Table 2). The population density in the control blocks was greater than that in the 20% recommended dose treatment blocks which in turn was greater than that in the 50% recommended dose sprayed blocks. All of these differences were significant ($p<0.05$). Percent parasitism was higher in August than in other months, indicating that parasites were the most active and abundant during this period of time. An interesting observation is the enhanced percentage of parasitism in the chemically suppressed populations except for those in August.

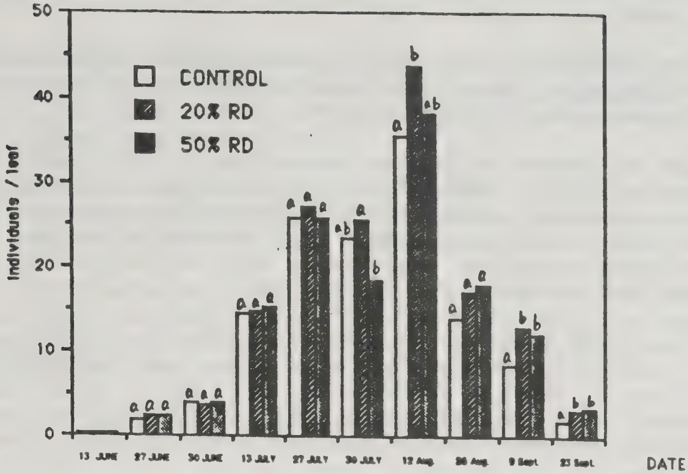


Fig. 1 Treatment effects on abundance of ERM over the season

Table 2. The effect of application of PP321 on tentiform leafminer and its parasites

treatment		13/7	27/7	30/7	12/8	26/8	9/9	23/9
control	N	83A*	524A	627A	186A	245A	631A	1028A
	%	3.6a*	11.1a	10.7a	68.3a	40.0ab	2.2a	2.3a
2.5g ai/ha	N	42B	145B	230B	70B	133B	133B	348B
	%	19b	23.4b	15.7a	70.0a	32.4b	3.1a	1.1a
6.26g ai/ha	N	30C	67C	108C	36C	51C	97C	82C
	%	30c	26.9b	13.0a	44.4b	45.1a	15.5b	9.8b

Note: N = individuals per 500 leaves % = parasitism percentage
* p = 0.05, Tukey test

13. HASTINGS, J.B. - Using pheromones as a mating disruption method in order to reduce subsequent larval damage by the grape berry moth.

In the Niagara Peninsula the major insect pest on grapes is the Grape Berry Moth (Endopiza viteana); it is estimated that it is responsible for at least 5% damage to the crop every year.

Growers have to contend with three generations of this insect during the growing season of the grape. This involves between 3-5 applications of insecticide, usually in combination with fungicide treatments. The timing of application is critical, and since very few growers are able to monitor the insect cycle themselves, they usually rely on the 'hot line' advisory service provided by OMAF at Vineland Station.

Whilst this service is invaluable to many growers, few of them are able to apply the insecticide on the optimum date for their particular vineyard for a variety of reasons, consequently the control of the GBM may be unsatisfactory. As a result quite a number of growers have turned to the use of `hotter chemicals' such as parathion in the hope that they will get better control.

The use of pheromones for mating disruption of GBM has now been investigated for a number of years in Europe and the USA, and it has been shown that by `saturating' an area with female GBM pheromone, the males become sufficiently confused so as not to be able to identify the females in that area, and mating is inhibited.

Since the pheromone is GBM specific and non-toxic, there are clear environmental advantages over the use of broad spectrum insecticides. Furthermore, the slow release pheromone dispensers eliminate the problems of spray timing, since the pheromone is present throughout the season.

The objective of the 1988 field trials was to establish whether the results that had been obtained in small plot trials in 1987 would be repeated in commercial field-sized plots, and whether they would compare favourably with standard insecticide programs in containing the amount of damage caused by the GBM larvae of each generation.

Three separate vineyards were selected where a pheromone plot and a control plot could be set up in close proximity, and where possible the surroundings and the grape varieties were similar. All the plots were approximately 4.0 ha in size, and growers carried out their normal cultural practices throughout the vineyard, with the exception that the pheromone plots were excluded from any insecticide spraying.

400 pheromone dispensers were attached at regular intervals along the trellis wires of the pheromone plots in early April, and Pherocon II insect traps baited with the same pheromone (Z-9 dodecenyl acetate + Z-11

tetradecenyl acetate) were set up in the pheromone plots, the control plots and the surrounding hedgerows as a means of monitoring male GBM activity.

Trap catch readings were made every two days at all locations on a total of about 200 traps, and larval damage was assessed for each generation. The sample plots each contained 20 vines and 10 clusters were sampled per vine (200 clusters per sample plot).

Samples were made throughout the three periods of larval activity at each of the three locations; more that 15000 clusters were non-destructively checked throughout the summer, both in the pheromone and control plots.

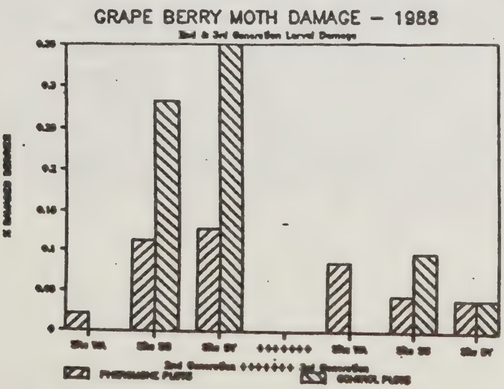
Growers were advised exactly when they should spray the remainder of their vineyard so that the spray application coincided with the appearance of GBM eggs and early larval stages, thus ensuring the best control against which the pheromone performance would be judged.

The results of the trials clearly showed that pheromone disruption took place, and that the amount of recorded berry damage compared favourably with the control plots that had been sprayed with three applications of insecticide, against the single application of pheromone (Fig. 1). Furthermore the level of damage was considerably below our threshold target of 2%.

The 'edge effect' in which the bulk of damage occurs around the edges of the vineyard, usually adjacent to hedgerows, was also clearly shown both in the pheromone and the control plots, and further work in addressing this problem is essential.

It is important to realize that at any time an insecticide treatment can be used in conjunction with a pheromone treatment should the necessity arise, giving the grower an additional security. However it was not necessary on these plots.

The introduction of pheromones for GBM control will initially require specialist support at farm level, but it could lead to the immediate reduction of at least 50% of the insecticide now being used on grapes in the Niagara Peninsula, at little or no additional cost to the grower.



14. HOFSTRA, G., M.STASIAK and R.A. FLETCHER - **The effects of sub-lethal levels of glyphosate on deciduous forest species.**

Objectives:

1. determine the no effect level for glyphosate on visual injury and the growth of seedlings of white birch, trembling aspen and alder.

2. determine the no effect level on physiological processes by measuring changes in leaf fluorescence, electric conductivity, chlorophyll and carotenoid content and changes in the shikimic acid pathway.

Progress Report

Seedlings of pin cherry, white birch and trembling aspen have been established either from seed or from seedlings dug up from the bush. Plants are being grown in pots in an enclosure at the University. White birch seedlings were sprayed with a range of concentrations from 100% of field rate (2.1 kg/ha) down to 1%. Regrowth will be measured in 1989 at various stages during the growing season. The seedlings of other species are ready for treatment in 1989.

A number of parameters have been measured on sprayed seedlings to determine sensitive physiological processes that could be used to assess sub-lethal effects. The chlorophyll and carotenoid content did not change in the older sprayed leaves until necrosis became apparent. However, young expanding leaves showed decreases in both the chlorophylls and the carotenoids in the absence of necrosis. Membrane leakage as shown by changes in electric conductivity did not change until necrosis became apparent and proved not to be a good parameter for measuring sub-lethal effects. Fluorescence increases as photosynthetic efficiency decreases, and measurements indicated injury to the leaves. By day 4 all treatments deviated significantly from the control, the effect increasing with the concentration of glyphosate (Table 1). Some recovery seemed to have taken place by day 8 except for leaves treated at the field rate. The values were still all higher than the control and some of these treatments did eventually show visible injury.

Glyphosate blocks the shikimic acid pathway causing a buildup of shikimate and a decrease in aromatic amino acids. Presumably death is caused by the lack of aromatic amino acids essential for protein synthesis. The techniques available for analysis of either shikimate or the aromatic amino acid were cumbersome and out of date. Considerable effort had to go into perfecting analytical techniques for analysis using HPLC, GC and colorimetric methods. HPLC and GC do not distinguish shikimic from quinic acid, but the colorimetric test does. A combination of tests may have to be run to ascertain the exact levels of shikimate.

Table 1. The effect of different concentrations of glyphosate on leaf fluorescence in young pin cherry trees 2, 4 and 8 days after spraying.

Glyphosate % of field rate	Fluorescence % increase over control Day 2	Day 4	Day 8
2	2.8	7.2	2.8
5	-2.8	12.2	5.9
10	0.7	8.0	5.1
25	2.9	12.4	6.6
100	9.6	26.9	42.0

Initial results indicate that pin cherry trees sprayed outdoors showed the greatest build-up of shikimic acid at 25% of field rate. Within 24 hours after spraying a rise in shikimate was detectable, with the greatest increase occurring about 4 days after spraying. By day 4 the concentration of shikimate was about 30 fold higher than the controls. By 8 days after spraying the level had dropped to less than half the maximum level, and by 30 days the level had dropped back to those of the controls. The time of the peak shikimic acid value corresponds to the time when fluorescence was most affected as well.

Analysis for one of the aromatic amino acids is partially completed. Phenylalanine did not decrease either with time or with increasing concentration of glyphosate. Phenylalanine showed an increase of about 4 fold on day 4 at 25% of field rate. These preliminary results are contrary to expectations if the pathway is blocked at shikimate. Analysis for the other aromatic amino acids is not yet complete.

Table 2. The increase in height and diameter of young pin cherry trees and the amount of foliar injury one year after spraying with a range of glyphosate concentrations.

Glyphosate % of field rate	% increase height	diameter	foliar injury %
control	9.6	18.3	8.4
2	5.0	14.3	16.8
5	14.7	16.3	11.2
10	6.7	5.9	29.7
25	7.5	-1.6	45.4
100	-2.8	-10.6	96.0

For woody plants the injurious effects of glyphosate accumulate over a longer period of time. A decline in vigour and increase in mortality continued into at least the year after which the spraying was done. Table 2 shows the changes in growth in the field and the amount of injury on the foliage one year after spraying with a range of concentrations.

Previous treatments in the field indicate that injury continues to develop over at least a year. If immediate kill of undesirable woody vegetation is not needed, lower field rates could suffice. The effect needs to be further detailed under more controlled conditions and the mechanism of continued injury further elucidated. The physiological parameters being measured so far have not been sensitive enough to reflect the low level of long term injurious effects as seen in reduced growth and injury on new foliage.

15. SIBLEY, P.K. and N.K. KAUSHIK - Toxicity of microencapsulated permethrin to selected nontarget aquatic invertebrates.

In the past year our research has focused on:

i) continued testing of microencapsulated (ME) permethrin (common name: Penncapthrin) to determine its toxicity toward nontarget aquatic invertebrates, and

ii) evaluation of how the addition of the polymer changes the dynamics of insecticide poisoning during toxicity tests.

In this respect, our efforts have focused on adsorption of both microcapsules and insecticide to laboratory glassware and its effect on estimating the LC50.

Toxicity tests were conducted using selected species from both lotic and lentic habitats. For streams, tests were conducted using three filter feeders, *Simulium vittatum* (blackfly), *Hydropsyche* sp. (caddisfly), and *Isonychia bicolor* (mayfly) and a scraper, *Ephemerella rotunda* (mayfly). For ponds/lakes, *Daphnia magna* and *D. pulex* were tested. The response of each species to penncapthrin along with a comparison to EC permethrin for *Daphnia* is presented in Table 1.

Lotic Invertebrates

The toxicity of penncapthrin to stream invertebrates is very low (Table 1), a point of obvious importance with respect to minimizing nontarget toxicity. Several interrelated mechanisms underlie the low toxicity of penncapthrin, including short exposure time, slow release of insecticide from the microcapsules, and a generally short residency period of microcapsules in the digestive tracts of exposed organisms.

The length of exposure for stream tests was 1 hour which was selected for its approximation of the **maximum** pulse likely to occur in most streams. In reality, exposure to a chemical in streams follows a typical time-concentration (pulse) curve where attainment of peak concentration and ultimately peak exposure occurs for a very short period of time (e.g. 15 minutes). Thus, toxicity may be even less than that predicted from our laboratory tests since exposure under these circumstances occurred at peak concentrations for the entire 1 hour test period. At the very least, it emphasizes the need to test ME formulations under field conditions.

It may be useful to consider exposure to ME insecticides as a two phase system in which there is an 'actual' or 'effective' concentration of insecticide (that which has leaked from the capsules and is available to invertebrates) and a 'potential' concentration which is unavailable due to its retention in the capsules. In streams, the pulse nature of pesticide exposure, in conjunction with the slow release of insecticide from the capsules, ensures that the actual concentration remains low. Selective uptake of capsules as a result of feeding activity, although possibly the most important route of exposure in stream invertebrates, does not appear to enhance toxicity since the vast majority of microcapsules remain unaltered during passage through the digestive tract. This may reflect the short residence time of the microcapsules within the gut or resilience to possible damage caused by movement through the gut environment.

Methods of food resource exploitation and particle size preferences are also important considerations. For example, the average size of net mesh in Hydropsychids is too large to retain microcapsules and thus exposure is reduced. Blackflies, however, actively filter particles that correspond in size to the average size of microcapsule (40 um). Toxicity is therefore lower (see Table 1). In contrast, the vast majority of food particles ingested by Isonychia do not exceed 5 um, well below the average size of a microcapsule. Toxicity was found to be much lower, although perhaps more so than can be accounted for by consideration of feeding habits alone.

Lentic Invertebrates

One of the interesting aspects of penncapthrin toxicity in static tests was the degree of variability between estimates. It's possible that differences in the extent of adsorption of both microcapsules and insecticide to laboratory glassware could produce such variability. For example, with microcapsules, we found that not only adsorption but also sedimentation resulted in a substantial loss of microcapsules after 24 hours from the water column (Table 2). Scanning electron micrographs of Daphnia digestive tracts indicate that ingestion is not an important poisoning route since few microcapsules were found. Thus, differences in capsule availability with respect to ingestion are not likely to be a significant cause of variation. However, it is likely that the close proximity of the microcapsules to laboratory glassware (as a result of adsorption) enhances adsorption of permethrin to the glassware upon leakage from the capsules. Thus, variation in microcapsule adsorption to the glassware would produce corresponding variation in the amount of available (unadsorbed) insecticide and ultimately in the response of Daphnia. Residue analysis is currently under way to quantify these parameters.

As with streams, there is a need to test the toxicity of microencapsulated formulations in lentic environments. Predicting the impact of ME insecticides in this habitat from laboratory tests is difficult. Factors

such as the rate of release versus the rate of degradation of permethrin and the extent to which the microcapsules and permethrin are adsorbed to organic matter must be considered. Some evidence from the literature suggests that peak concentrations in ponds exposed to ME formulations of one insecticide are generally much lower than those associated with other formulations of the same insecticide. As such, nontarget impact could be comparatively lower.

Table 1. Toxicity of penncapthrin toward several aquatic invertebrates. Numbers in parenthesis represent the number of tests conducted. Superscripted letters different from each other represent significantly difference values (SAS: ANOVA, p= 0.05).

Organism	Chemical	Average LC50 Estimates/time 48	72	96
LOTIC (PPM)				
Simulium vittatum	penncapthrin			3.11a(12)
Hydropsyche sp.	"			4.91a(10)
Ephemerella rotunda	"			3.47 (1)
Isonychia bicolor	"			13.41b (2)
LENTIC (PPB)				
Daphnia magna	penncapthrin	---	818.67a	9.61
	EC permethrin	---	14.62c	
Daphnia pulex	penncapthrin	---	73.56b	0.50
	EC permethrin	24.88	6.08c	---

Table 2. Microcapsule adsorption/sedimentation in relation to exposure time and concentration of penncapthrin.
Note the variation between estimates.

Concentration (mg/1)	Time (hrs)	Rep	# of Microcapsules Water	Beaker
0.50	24	1	301	1020
		2	698	1446
		3	544	1038
		1	1597	2068
1.00		2	1618	1404
		3	862	1401
0.50	48	1	61	869
		2	147	625
		3	48	840
		1	149	1359
1.0		2	165	1526
		3	77	1606

16. KEVAN, P.G., D. EISIKOWITCH, M.A. LACHANCE, and D.L. COLLINS-THOMPSON - Using yeasts to suppress seed production in field milkweeds.

In Asclepias, nectar is secreted by the stigmatic chamber and has two functions: a) the carbohydrate reward for pollinating insects which the plants require for sexual reproduction and b) germination medium for pollen. The nectar easily becomes infected by yeasts, mostly Metschnikowia reukaufii. Nectar from flowers which opened in the laboratory were yeast-free and did not inhibit pollen germination but samples of nectar from older, open flowers from the field almost always were inhibitory (94-98%) and supported populations of yeast. When nectar from buds which opened in the laboratory or artificial nectars (solutions of D-glucose and sucrose which normally support vigorous germination of pollen) were contaminated with yeast-infected nectar, they did not support pollen germination. Yeast-infected nectar or sugar solutions which were filtered to remove the yeast cells were also inhibitory.

Selections were made from field collected yeasts in 1987 and 1988. Two strains, and their mixture were tested on pollinia. They affected pollen germination adversely by reducing its amount, vigour, and causing any pollen tubes that were produced to burst. One of the strains tested was more virulent than the other, and the mixture seemed to have an additive effect. The strains may be more efficacious in disrupting fertilization of milkweed flowers because they cause the immediate death (bursting) of

the growing microgametophyte (pollen and tube).

Five different yeast selections were compared in the field for their ability to control fruit-set of milkweed. The selections included selected M. reukaufii types and a Candida sp. frequently recovered from milkweed nectar. Yeast strains were grown, harvested by centrifugation, washed with sterile 10% glycerol, and stored at -70^{o} C until ready to use. At time of application, cells were thawed rapidly at 37^{o} C and diluted in tap water in spray bottles. Viability was ascertained periodically. Young inflorescences of individual plants were sprayed at weekly intervals until new antheses were no longer observed. Sprayed specimens formed on the average 3 fruits per inflorescence, not significantly different from non-treated plants, but fruits were generally smaller. The different treatments were not significantly different. It should be noted that the plants were visibly stressed by the serious drought conditions experience in June and July 1988.

Seven strains of M. reukaufii were tested for extracellular enzymes in the presence of 10% sucrose. Three strains had either weak lipolytic or weak gelatinase activity. Such activity could not be directly associated with inhibition of pollinia germination of Asclepias syriaca. During the growth of the 7 strains it was shown that sucrose was not the prime carbon source nor was it utilized during growth of these strains. Sucrose concentration however was important for growth. The yield of one strain increased with the increasing sucrose concentration (10% < 20% <30%). This indicates that M. reukaufii is an obligate osmophile (requires high osmotic pressures to grow).

Analysis of nectar samples from bagged and unbagged flowers suggested higher levels of sucrose in the bagged ones. The nectar samples in unbagged samples contained volatile alcohols including ethanol, indicating fermentation. Further work is required to characterise the nectar, the microflora in nectar and products before the role and mode of action of M. reukaufii can be clarified in the inhibition of polliniae germination of Asclepias syriaca.

We made a major collection of yeasts from insects captured on milkweeds. Moth and bumblebees harbored the largest numbers of yeasts, both on their body surfaces and mouthparts. Honeybees had slightly fewer, but they appeared to carry the largest numbers of cells of M. reukaufii. Other insects (milkweed beetles, flies, ladybugs, and ants) vectored yeasts as well, but in much lesser numbers. Overall, the numbers were much larger than anticipated, so that most samples could not be enumerated accurately as to the proportions of every yeast type. The study must therefore be repeated based on our observations, and adjusting our sampling technique accordingly, even though we are assured of the value of insects as vectors of the yeasts.

Preliminary research was initiated on how to maintain the organisms.

Cryopreservation facilities were set-up for poorly viable isolates. Surviving yeast strains collected in milkweeds from Ontario, Quebec, and New York State were stored in liquid nitrogen, and tests were conducted to see if viability was maintained. Our results indicate that liquid nitrogen is very satisfactory for the maintenance of Metschnikowia and related milkweed yeast isolates.

The prospects of selecting strains and using them as biocontrol agents against milkweed sexual reproduction has been forwarded for possible patentability. Positive preliminary responses have been received.

17. McLEOD, D.G.R., A.D.TOMLIN, J.H. TOLMAN, and J.W. WHISTLE-CRAFT - Assessment of the potential of Aleochara bilineata for the control of root maggots in the home garden.

Aleochara bilineata (AB) is a parasitoid of several root maggot species including the cabbage maggot (CM) and the onion maggot (OM). As these two pests occur in nearly every home garden tested, it was decided to see if this parasitoid could prevent damage to radishes and onions in the home garden. This is the second year of these trials.

Last year the results demonstrated that AB released at the rate of 1000/wk was able to reduce significantly CM damage in radishes, but was not nearly as effective in controlling OM damage in onions. This year, we wanted to investigate the relationship between numbers of AB released and degree of control of root maggots in radishes and onions.

The number of gardens was increased from 24 to 28 which were divided into four groups. The 7 gardens in Group A served as the control and did not receive any AB. Groups B, C and D received 250, 500 and 1000 AB/wk, respectively, from the beginning of May until the beginning of September-19 weeks in total.

Four plantings of radishes, two of Dutch sets and one of bunching onions spread throughout the season were used to assess damage caused by native populations of CM and OM, respectively, and to assess the protection afforded by releasing different levels of AB.

Populations of adult OM and CM as well as several other pests and beneficial insects were monitored with yellow pan water traps. Native and released AB and other soil arthropods were monitored with barrier pitfall traps. Collections were made from both types of traps once per week.

Soil samples were taken for organic matter determination, nutrient analysis and soil type classification. Six 'home garden' plots were set up at the Agriculture Canada Field Station. The 6 treatments were: (A)=control (no AB), (B)= 250 AB/wk, (C)= 500 AB/wk, (D)= 1000 AB/wk, (E)=5000 AB/wk, and (F)=insecticide (5% diazinon granules at planting).

Populations of CM and OM were about 1 wk later this year than last due to a slightly cooler spring. Populations of CM were about twice as high as last year, while OM populations were about equal. Coenosia tigrina, the tiger fly, were present at only 1/5 the 1987 level. In all cases, roughly equal numbers of insects, on average, were recorded in each of the 4 treatments.

The extremely hot weather of late July and early August apparently delayed the emergence of the third generation of both OM and CM and in the case of CM, reduced it to a very low level. The results indicate that AB were able to reduce damage caused by CM in the first two plantings of radishes. Released at the rate of 250 or 500/wk, damage was reduced by about one-half. A further reduction by half was accomplished by increasing the release rate to 1000/wk (Table 1). Results in the last two plantings were not significantly different - one reason being the very hot temperatures which reduced both radish and CM populations.

OM damage was not significantly reduced in those gardens with AB, even at the high rate of 1000/wk (Table 2). The reasons for this are not clear.

The 'home garden' plots at the Field Station provided useful information only for the first two plantings of radishes. Tremendously high populations of flea beetles and drought destroyed the 3rd and 4th radish plantings and extremely low populations of OM resulted in zero damage in onion plantings. Results with the first two plantings of radishes showed the general trend to lower damage with higher release rates but not significantly so (Table 3). The reason for the failure of the insecticide treatment is not clear, but may be a result of loss of predators and parasites.

TABLE 1 Radish Results - 1988

Treatment	Planting 1	2	3	4	Average
Control	28*	30	8	12	19.5
250/wk	17	22	1	3	10.7
500/wk	22	16	4	1	10.7
1000/wk	10	9	4	4	6.7

* % damage

These results are in good agreement with those of last year, in that AB reduced CM damage in radishes and also demonstrated the relationship between numbers of AB released and amount of damage in radishes. Increasing the number of AB released to 2000/wk in the 'home gardens' set up at our Field Station did not significantly increase the amount of control in the first two radish plantings. Results indicate there was little, if any, control by AB of OM damage in onions.

TABLE 2 Onion Results - 1988

Treatment	Planting 1(sets)	2(sets)	3(bunch)	Average
Control	30*	42	5	25.7
250/wk	18	36	2	18.7
500/wk	13	41	13	22.3
1000/wk	13	32	1	15.3

* % damage

TABLE 3 Radish Results - Field Station 1988

Treatment	Planting 1	2	Average
Control	22*	7	15
250/wk	37	3	20
500/wk	7	7	7
1000/wk	0	17	8
2000/wk	2	3	3
Insecticide	18	27	23

* % damage

18. NEALIS, V. and S.M. SMITH - Improving the biological control potential for gypsy moth in Ontario through the introduction of new strains of the parasitoid, *Cotesia melanoscela*.

Cotesia melanoscela is a common insect parasite (parasitoid) of the early larval stages of the gypsy moth, *Lymantria dispar*. It was originally introduced from Europe into the United States and has dispersed with the gypsy moth so that it is now found throughout the range of its host. Despite the success of *C. melanoscela* at establishing in most areas infested by the gypsy moth, the parasitoid does not seem to have any regulatory effect on gypsy moth populations. One explanation is that *C. melanoscela* is itself limited by secondary or hyperparasitoids.

Current biological control activities against gypsy moth in the US involve the release of parasitoids from the Orient and inundative releases of parasitoids which are commercially mass-produced in the US. At least 4 species of these parasitoids are similar enough to the naturalized *C. melanoscela* that they may be attacked by the same species of hyperparasitoids. This would reduce their effectiveness. Before undertaking the expense and uncertainty of new introductions, it would be worthwhile to examine how important hyperparasitism is in Ontario and which, if any, of the parasitoid species available for release are the least susceptible to hyperparasitism.

Our objectives in this study are;

1) To develop methods to quantify the impact of hyperparasitism on *C. melanoscela* and related species.

2) To apply these methods to the estimation of the impact of hyperparasitism on Ontario populations of C. melanoscela.

3) To assess the feasibility of releasing new parasitoids based on their susceptibility to hyperparasites.

In 1988 we focussed on objectives 1 and 2. We developed and tested a method for monitoring and measuring hyperparasitoid attacks in the field. Cotesia melanoscela larvae are induced to spin cocoons on bark disks and then these disks are taken to the field and placed on trees at fixed locations for pre-determined periods. This technique allows manipulation of both spatial and temporal aspects of exposure of C. melanoscela cocoons to hyperparasitism.

To determine the seasonal occurrence of hyperparasitoids, we sampled at one plot at weekly intervals from 7 June to 18 August. Hyperparasitoids were not recovered until 21 June and were then found in each subsequent exposure period.

To examine the spatial distribution of hyperparasitoid attacks, we placed bark disks on two tree species (red and white oak), at two heights (chest height and 8 m) and on north and south sides of the tree. Because C. melanoscela populations in Ontario can consist of either diapause or nondiapause individuals, we also compared the susceptibility of these two kinds of cocoons at each spatial arrangement.

A series of contingency table analyses showed that of all factors examined, differences in the rate of hyperparasitism were only significant when diapause and nondiapause cocoons were compared. Hyperparasitism was relatively more frequent on diapause cocoons. We hypothesize that diapause cocoons may be more vulnerable to hyperparasitism because, unlike nondiapause individuals which are continuously developing and emerging from their cocoons, diapause individuals are dormant and remain as soft larvae within their cocoons for months.

To develop a laboratory rearing method for experimental purposes, three of the most common hyperparasitoid species have been colonized. A series of preliminary trials have been completed to determine a correct exposure method, period and ratio of hyperparasitoid adults to cocoons. We are now in the position to rigorously test the relative susceptibility of the different types of parasitoids to hyperparasitism.

Our initial experiments were with cocooned C. melanoscela at various stages of development ranging from newly-spun cocoons with mature larvae inside to partially sclerotized adults. These experiments revealed that the 3 species of hyperparasitoids were capable of attacking all stages of the cocooned C. melanoscela although the rate of successful attack appears to be reduced on the older individuals. This supports our hypothesis that vulnerability to hyperparasitism decreases with development of the host. Also of interest was the rate of hyperparasitized-induced mortality in the experiments. We are currently trying to determine to what extent this is a laboratory artifact. If real, this induced mortality may account for unexplained failure to emerge in some field-collected C. melanoscela and would further emphasize the impact of hyperparasitoids on this species.

The laboratory program has also helped improve our method of producing sentinel cocoons on bark disks so that even more experimental control can be exercised in the next field season.

Plans for the next year include maintenance of colonies of hyperparasitoids and further examination in the laboratory of the relative susceptibility of different kinds of parasitoids depending on what species can be made available through the Canadian Forestry Service. During the field season, we plan to further quantify the relationship between the distribution of C. melanoscela cocoons and hyperparasitism and to quantify the impact of these hyperparasitoids on the effectiveness of C. melanoscela as a biocontrol agent of the gypsy moth.

19. RIPLEY,B.D. and G. RITCEY - Comparative behaviour of pesticides with respect to worker safety. 1. Re-entry intervals. 2. Dislodgeable residues.

A comparative study was conducted on residue deposits, their lodgeability /dislodgeability, and dissipation from a tank mix of nine pesticides on strawberry plants and fruit. As shown in Figures 1 & 2, wide differences in behaviour between these pesticides were apparent. For example, residues of parathion and diazinon showed a very rapid decline (>99% within 4 days) on strawberry leaves while iprodione and dimethoate were more persistent. Parathion residues that remain on plants were mainly lodgeable. Cypermethrin residues were very persistent and were not easily dislodged. Residues of both carbofuran and iprodione (Figure 2) were easily dislodged; carbofuran residues were very quickly dissipated from foliage whereas iprodione residues persisted for greater periods of time.

These comparative studies are useful to confirm re-entry intervals and potential exposure of applicators and farm workers. While many of these behaviours may be predicted from models using physico-chemical properties, models need to be verified and the particular behaviour of each pesticide described under specific conditions.

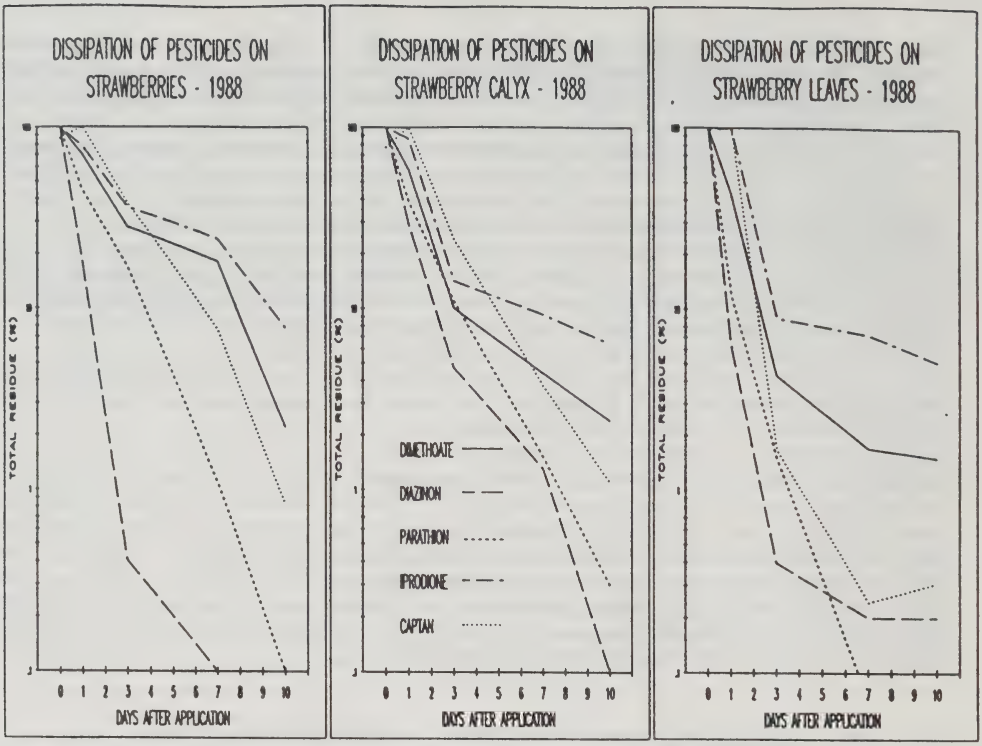


Figure 1.

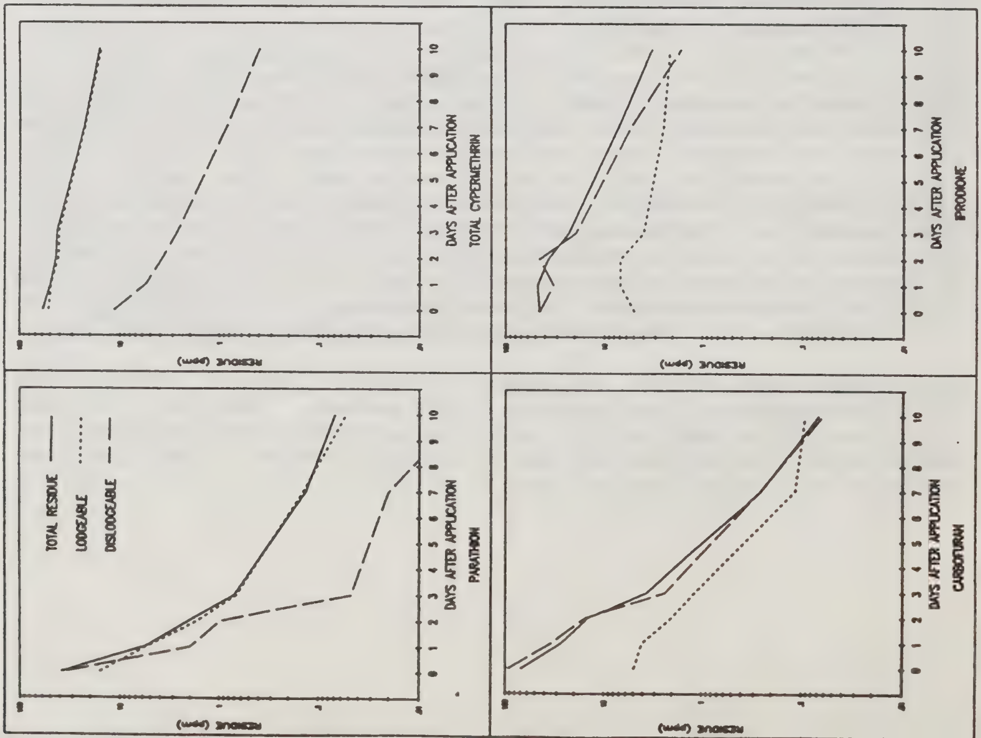


Figure 2.

19b. RIPLEY,B.D., M.R.McDONALD, and G.RITCEY - Pesticide Exposure to Integrated Pest Management (IPM) Scouts From Treated Fields.

IPM scouts entering pesticide-treated fields may be exposed to residues remaining on the crop. Scouts, wearing cotton leggings and gloves, conducted their normal IPM duties in growers fields. After 15-20 minutes, the gloves and leggings were placed in bottles and submitted for residue analysis. Analysis indicated that large amounts of residue can be transferred from plant foliage or soil to the scouts. Additional studies are required to quantify the exposure and to determine appropriate remedial measures.

20. SANDERS, C.J., - Control of spruce budworm by mating disruption: Effects of different pheromone blends.

The overall goal of this project is to determine the efficacy of synthetic spruce budworm pheromone for regulating spruce budworm populations. Field trials have been carried out since the 1970s, including aerial applications, but the efficacy is still questionable. This study addresses two points: i) the optimum pheromone blend, and ii) the efficacy of different formulations.

i) **Blend:** The natural blend is a 95:5 mixture of (E:Z)-11-tetradecenal. The racemic 80:20 blend is cheaper, but may be less effective. Therefore, different blends were assayed in the laboratory and field to determine the importance of the blend in disruption.

ii) **Formulations:** Special formulations are required to protect the chemicals form degradation, and to release them at a uniform rate over a 4 week period. Formulations range from extremely small particles (down to 5 microns) such as microcapsules, up to plastic chips of fibers, which release pheromone at rates of 1000x a female. These may affect the moths differently, which in turn may affect efficacy.

Experiments

Laboratory assays were carried out in a wind tunnel, 2 m long and 1 m^2 in cross section. Pheromone was loaded into rubber septa which were then pinned to the upwind screen of the tunnel. Female moths in small screen cages were placed in front of the screen. Males were released at the downwind end of the the tunnel and the numbers locating the released females against the background of pheromone recorded. Four blends were tested, 100:0, 95:5, 80:20 and 50:50. Two configurations were tested: 9 septa, each loaded with 1 ug pheromone, and 81 septa, each loaded with 0.1 ug pheromone (ie approximately the same total amount of pheromone).

The results, Fig. 1, show that the 9 x 1ug treatment was generally more effective, although differences were not significant. Maximum disruption occurred with the 95:5 blend, but, again differences were not significant.

Possibly the experiment was not discriminating enough, and it is proposed to repeat the experiments using a 3-dimensional array of pheromone releases to mimic the field situation.

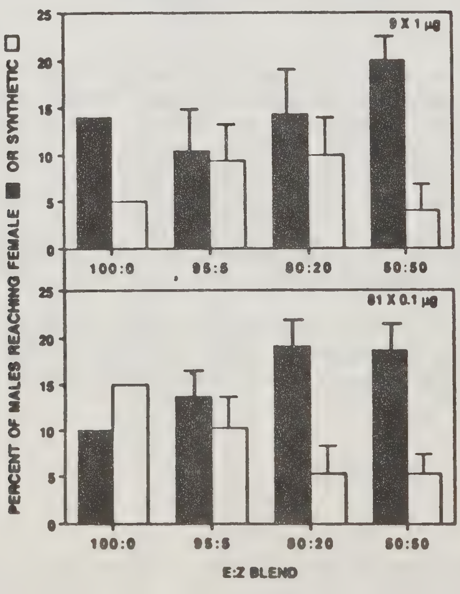
For the field experiments three blends were formulated in PVC pellets, 95:5, 80:20, and 50:50, one series at 0.3% pheromone by weight to provide a high release rate, one at 0.003%. A lattice work of string was set up in 6 plots. For the high release-rate formulation, pellets were attached at every intersection (ie $1/m^3$ which simulates an aerial deposit rate). For the low-release formulation, the same lattice of 0.3% pellets was used, but in the central core area of 2 x 2 m the 0.3% lures were substituted by 0.003% lures at a density of $100/m^3$. Female moths were placed in traps in the centre of each plot in two check plots. Differences between moth catch in treatment and check indicated the degree of disruption.

Results (Table 1) showed excellent disruption in all treatment plots, but no differences among the blends or between types of array. Evidently the pheromone concentrations were too high to detect differences, and it is proposed to repeat the experiment in 1989, using fewer pellet dispensers.

Table 1. Percent reduction in trap catch (check treated/check x 100) in plots treated with three different pheromone blends in two different configurations

	Pheromone Blend		
Plot configuration	95:5	80:20	50:50
High release pellets	93.1+/-7.7	97.2+/-5.9	98.8+/-1.3
Low release pellets	93.9+/-11.8	98.2+/-2.2	98.6+/-3.1

Figure 1. Percentages of male spruce budworm moths flying to female moths in the presence of competing synthetic pheromone lures in a wind tunnel. Nine lures each loaded with ug synthetic (top), or 81 lures loaded with 0.1 ug (bottom).



21. STEPHENSON, G.R., C.S. BOWHEY, K. CHRISTIANSEN and J.C. HALL- **Methods for minimizing dislodgeable residues for 2,4-D in turfgrass situations.**

In previous studies of this type, we have observed that dislodgeable residues of 2,4-D were quite low, even immediately after spraying. At 0 time, only 5-6% of the 2,4-D applied as a spray could be dislodged by physical scuffling. This decreased rapidly so that dislodgeable residues were less than 1% of applied after 4-5 days. At equivalent rates of application, on a kg/ha of active ingredient basis, 2,4-D applied as granular-fertilizer formulation was less dislodgeable than 2,4-D applied as a spray. In a study where clippings were not removed, moving had little effect on the disappearance of dislodgeable 2,4-D residues. However, rainfall whenever it occurred, immediately reduced dislodgeable 2,4-D residues to insignificant levels.

OBJECTIVES
The goals of the present study were to examine the effects of (1) intentional irrigation (2) mowing, with and without removal of clippings and (3) formulation, 2,4-D granulars (at recommended rates for each) as methods to minimize dislodgeable 2,4-D residues without reducing the efficacy of 2,4-D for weed control.

METHODS
Field plots were established at the University of Guelph, Cambridge Research Station on an established stand of Kentucky Bluegrass/Annual Bluegrass (Poa pratensis /Poa annua) turf. Plots were sampled by physical scuffling with bag-and cheesecloth-covered boots. The cheesecloth samples were returned to the laboratory in acidified acetone for extraction, cleanup, and analysis by gas liquid chromatography. All treatments had five replications and all studies were conducted at least twice.

The Effect of Mowing. Three treatments were applied in this study; a) mowing with clipping removal b) mowing with the clippings left on, and c) no mowing. All plots received 1.1 kg ai/ha 2,4-D amine applied as a spray in 500 1 of water/ha. Sampling was done on day 0, on day 1, before mowing and again on day 1 after mowing, and finally on day 2.

The Effect of Irrigation and Formulation. Liquid 2,4-D amine was applied to the plots as a spray at 1.1 kg ai/ha in 500 L of water. Granular 2,4-D (1% 2,4-D amine on Beaver Lumber 10-6-4 fertilizer) was applied at the recommended rate of 5 kg ai/ha. Sampling was done at day 0 and day 1, and again on day 1 after 20 minutes irrigation, and finally on day 2.

RESULTS

Effects of mowing. On the day of treatment, dislodgeable residues of 2,4-D sprays, were less than 5% of applied or 4 or 5 mg/m^2 of turfgrass. Residues in all three plots dropped to approximately 2.5% of applied on day 1. Mowing the turf on day 1, without removal of the clippings, did significantly reduce dislodgeable 2,4-D compared to un-mowed plots. However, the decrease was less than 1% and would have little practical significance.

Effects of formulation and irrigation. On the day of treatment, dislodgeable residues were 6 and 7 mg/m^2 for 2,4-D applied at 1.1 kg ai/ha as a spray and 2,4-D applied at 5 kg ai/ha as a fertilizer granular, respectively. On day 1 dislogeable residues for the 2,4-D sprayed treatments decreased from 7 mg/m^2. In contrast, dislodgeable residues increased from 6 to 7 mg/m^2 from day 0 to day 1 for the 2,4-D applied as a fertilizer granular. Irrigation on day 1 immediately reduced dislodgeable residue for the spray and the granular treatments to less than 0.25 mg/m^2 and dislodgeable residues of 2,4-D were barely detectable by day 2.

Effects of irrigation on 2,4-D effectiveness. Preliminary evaluations from two field studies indicate that irrigation as early as 6 and 12 hours after application did not decrease the efficacy of 2,4-D sprays or granular treatments for control of dandelions.

CONCLUSIONS

Custom applicators of pesticides in public turfgrass areas generally experience less concern or fewer objections to the use of granulars as compared to sprays. On an equal rate (kg ai/ha) basis, there is a lower risk of exposure to dislodgeable residues of 2,4-D granular compared to 2,4-D liquid spray. However, for equal effectiveness, higher rates are required for 2,4-D applied as a granular (5 kg ai/ha) than for 2,4-D applied as a spray (1.1 kg ai/ha). At recommended rates for both, we observed, in this study, that dislodgeable residues were very similar on day 0 and on day 1 they were actually higher for the granular fertilizer formulation of 2,4-D. Mowing had very little effect on the disappearance of dislodgeable 2,4-D residues in turfgrass regardless if clippings were removed or not. However, a prescribed light irrigation (20-30 min) is the obvious way to minimize the time during which there would be a chance for exposure to dislodgeable residues of 2,4-D or other turfgrass pesticides. More research is needed to determine how soon treated areas could be irrigated without reducing the effectiveness of various turfgrass pesticides. However preliminary studies indicate that irrigation as soon as 6 or 12 hours did not reduce the effectiveness of 2,4-D for control of dandelions.

22. STEPHENSON, G.R., C.S. BOWHEY, and Z. EKLER - **Persistence, mobility and activity of sulfonyl urea herbicides in an Ontario soil.**

A field study was initiated in June 1987 and continued through November 1988 to examine the chemical and biological persistence of chlorsulfuron in Guelph loam, an Ontario Agricultural soil. Samples collected during 1987 were analyzed in a private laboratory by gas liquid chromatography and data will be available early in 1989. Samples collected during 1988 are currently being analyzed. Companion samples were collected throughout 1987 and 1988 to permit a comparison of chemical assay with bioassay of the persistence of chlorsulfuron and the leaching of chlorsulfuron to depths of 0-10 cm, 10-20 cm, and 20-30 cm in the soil.

Bioassay studies with corn, wheat, sunflower, peas, lentils, faba beans, and alfalfa indicated that lentils and alfalfa were the most sensitive bioassay plant for picloram, a more established and more widely used herbicide which was included in the study for comparison purposes. Concentrations of chlorsulfuron as low as 0.1 ppb (ug/kg) in soil still caused visual and quantifiable injury to lentils and alfalfa. The "no-effect level" for chlorsulfuron with the most sensitive plant species in our study was 0.01 ppb (0.01 ug/kg soil). At present the detection limit for chlorsulfuron in soil with gas liquid chromatography techniques is approximately 0.2 ppb (0.2 ug/kg). Thus, there is definitely the chance for biological activity at levels which cannot yet be detected chemically.

Bioassays with lentils of undiluted soil samples indicate that phytotoxic residues of chlorsulfuron are still present 16 months after the application of 100 g/ha. There was also evidence that chlorsulfuron had leached to the 20 to 30 cm depth in the soil. All soil samples which were positive for chlorsulfuron in the undiluted bioassay will be diluted 1 to 10 and 1 to 100 with untreated Guelph loam soil. Bioassays will be employed to determine the levels of biologically active residues present after various times and at various depths in the soil core samples.

In comparative soil mobility studies with soil thin layer chromatography, three sulfonyl urea herbicides: chlorsulfuron, sulfometuron methyl and metsulfuron methyl were moderately to highly mobile in Guelph loam soil. Mobility was greater when the pH of the soil solution was increased but co-treatment with increasing levels of simazine did not alter mobility.

23. GLOFCHESKIE B.D. and G.A. SURGEONER - Management of house flies by sanitation - Impact on resistance/non-chemical alternatives.

Throughout 1987, and until May 1988, weekly manure management was maintained on a dairy farm to control house flies. This facility had a previous history of severe insecticide resistance. For example, in the fall of 1981 house flies were 208 fold resistant to permethrin (LD_{50}=.625% solution) when compared to the WHO susceptible house flies (LD_{50}=.003% solution). The program involved three hours of labour weekly at an approximate cost of 15 dollars per week. By the fall of 1987, the resistance ratio to permethrin had declined to 5.5 fold (LD_{50}=.067% solution) under a regime of sanitation and one required pyrethrin spray.

In the fall of 1987, a release program of susceptible flies (London strain LD_{50}=.0113% solution) was initiated to determine if resistance could be lowered further. Approximately 1000 marked susceptible house flies were released at 3 week intervals until the end of May 1988. Mark/recapture studies using "Silva" flypaper demonstrated that a ratio of at least 10 susceptible to 1 resistant house fly was maintained. The resistance ratio dropped to 1.3x after the release of susceptible flies.

The sanitation program was terminated to allow house fly numbers to increase. The objective was to initiate operational permethrin sprays to determine if susceptibility was stable.

The first spray (July 4) achieved >99% control as determined by a 5 minute fly count 1 hour after spraying. As there were no survivors, we could not determine a resistance ratio.

A second spray on July 25 achieved an 84% reduction and survivors were colonized. The resistance ratio had increased to 11.7 fold relative to the WHO strain. More importantly, the slope of the resistance line altered and some highly resistant individual flies were now present. This indicates that resistance would "rebound" rapidly in the population.

Other promising "non-chemical" fly control strategies are being assessed in the laboratory. These include flypaper, fly attractant traps ("Fly terminator") and Muscovy ducks. In 0.22 m^3 cages, Muscovy ducks caused a 92% reduction of adult flies in one hour and 100% reduction by 7 hours based on 9 observations and a density of 100 flies per cage. At a density of 400 flies, the 1 hour reduction was 79% (ie., 315 flies were eaten in one hour) and 100% reduction in 7 hours. The Muscovy ducks are out performing "Moskit" flypaper, "Silva" flypaper and the "Fly Terminator" fly traps. Ducks penned with calves consumed an average of 25 flies in 15 minutes based on 4 observations. At times this constituted up to 5% of the flies observed in the barn.

24. SUTTON, J.C. and G. PENG - **Evaluation of candidate organisms for biocontrol of grey mold in strawberries.**

The overall goal of this research is to develop practical biological control of strawberry grey mold as an alternative to chemical control. Areas of the work addressed in 1988 were isolation of candidate organisms for biocontrol, development procedures for screening the candidates, evaluation of the biocontrol activity of the candidates, studies on effects of nutrients on biocontrol, and preliminary tests for timing the application of biocontrol agents.

More than 300 isolates of bacteria, yeasts and mycelial fungi were obtained from strawberries in various locations in 1988. The isolates are being maintained and systematically evaluated as biocontrol against the grey mold pathogen, *Botrytis cinerea*.

For screening candidate organisms for biocontrol, leaf discs and petals were cut from strawberry plants grown in controlled environment and washed in sterilized distilled water. Inocula of *B. cinerea* and bacterial candidates and fungal candidates were produced on strawberry fruit agar, potato dextrose agar and nutrient agar, respectively, under standardized conditions. Suspensions of 10^6 spores/ml water of *B. cinerea* and candidate mycelial fungi, and 10^7 CFU/ml water of candidate yeasts and bacteria were used for inoculations. The suspensions were applied to the leaf discs and petals with atomizers. Each candidate organism was inoculated with *B. cinerea* or inoculated 48 h before *B. cinerea*. Inoculated tissues were incubated on nylon mesh in a humid atmosphere until 48 h after inoculation with *B. cinerea*, then transferred to paraquat agar to kill the tissues and provide conditions conducive to sporulation of the pathogen. Incidence or density of sporulation provided a means for estimating biocontrol of *B. cinerea*. Representative results are given in Tables 1 and 2.

TABLE 1. Effects of biocontrol candidates on sporulation by *Botrytis cinerea* on strawberry leaf discs.

Biocontrol candidate	Incidence of sporulation (%)	Density of sporulation (0-5 scale)
Water	100 a[1]	4.8 a
Trichothecium	100 a	2.2 d
Yeast #3	70 b	1.8 e
Isolate 217	17 c	0.2 f
Isolate 800	0 d	0.0 f

P =< 0.05, Duncan's new multiple range test.

Seven biocontrol candidates were evaluated for suppressing grey mold on petals, sepals and fruits of strawberries in replicated field plots (Table 3). Tagged blossom clusters on strawberry plants were inoculated with spores or vegetative cells of the various candidates suspended in sterilized-distilled water. Inoculum of each agent was applied five times at five-day intervals beginning at the green bud stage. Half of the plots also were artificially inoculated with B. cinerea. In plots exposed only to natural inoculum of B. cinerea, all candidates suppressed the pathogen on the petals, but only two yeasts did so on the sepals (Table 3). Sporulation densities were low in all plots, including the checks. In plots inoculated with B. cinerea, two fungi (A. alternata and yeast #3) suppressed disease on the petals and sepals, and bacterium #1 and yeast #2 did so on the sepals. Some organisms promoted disease. Extraordinarily hot weather severely constrained fruit growth and no fruit rot data were obtained.

TABLE 2. Effects of biocontrol candidates on incidence of sporulation by *Botrytis cinerea* on detached strawberry petals.

Biocontrol candidate	Sporulation incidence (%)
None (water check)	53 a[1]
Bacterium #1	66 a
Trichothecium roseum	16 b
Gliocladium roseum	26 b
White yeast	16 b
Pink yeast	3 c

P =<0.05, Duncan's multiple range test.

Effects of various simple sugars amino acids and yeast extract on grey mold were examined in field plots. The nutrients were applied 5 times at 5-day intervals beginning at the bud stage. Most nutrients suppressed sporulation on the petals by 30-45% and on the sepals by 24 to 76%. Fruit rot could not be assessed.

CONCLUSIONS

Several organisms suppressed B. cinerea in tests on strawberries in controlled environment and in the field. Relative effectiveness of the organisms on petals and sepals or leaf discs often differed. A pink yeast (#3), however, showed high promise on all tissues both in controlled environment and in the field.

Table 3. Effects of biocontrol candidates on grey mold in field plots assessed by estimating density of sporulation by B. cinerea on the petals and sepals.

Biocontrol candidate	Estimated density of sporulation of B. cinerea (0-5 scale)			
	Natural B. cinerea		Sprayed with B. cinerea	
	Petals	Sepals	Petals	Sepals
Water (check)	1.7 a	0.4 b	2.7 d	1.7 b
Yeast #1	1.3 b	0.0 d	3.3 a	1.5 b
T. roseum	0.9 c	0.2 b	3.3 a	1.4 b
G. roseum	0.7 cd	0.5 a	3.2 b	1.6 b
B. subtilis	0.6 cd	0.4 b	3.0 cd	2.2 a
Yeast #2	0.6 cd	0.3 b	2.9 cd	0.7 d
Bacterium #1	0.8 cd	0.3 b	2.5 d	0.9 d
A. alternata	0.6 d	0.3 b	2.4 e	1.3 c
Yeast #3	0.6 d	0.1 cd	1.8 f	0.1 e

P = 0.05, Duncan's new multiple range test.

25. MALIK, V., C.J. SWANTON and T. MICHAELS - Impact of white bean cultivars, spacing and seeding rates on establishment and suppression of annual weeds.

The trend in white bean cultivar improvement in North America is towards the development of plants with an upright architecture. This plant architecture may alter the competitive ability of the white bean plant against weeds and may influence subsequent weed control measures.

The potential need for full season weed control by herbicides in the white bean crop may be reduced by planting competitive cultivars of white beans. The competitive ability of the cultivar may be enhanced by determining the optimum seeding density and row width in order to suppress emerging annual weeds. Therefore the objectives of this study were to 1) determine the natural competitive ability of white bean cultivars against weeds, and 2) determine the influence of seeding rate and row width on suppression of emerging annual weeds.

Field experiments were conducted in 1988 at the Elora Research Station, Elora, Ontario on a loamy soil with pH 5.8 and organic matter content of 4.4 percent. OAC Gryphon (non-upright, semi-determinate), OAC Spring (determinate bush) and an experimental breeding line OAC 87-2 (upright semi determinate) cultivars of white beans were evaluated for their competitive ability against weeds under a regime of variable crop row spacings and seeding rates. A factorial design with strip-split plots and four replications was planted at seeding rates of 225,000 (normal) or 375,000 (high) plants per hectare under row-to-row distances of 69 cms

(wide), 46 cms (medium) and 23 cm (narrow). The individual plot size was 12 x 2.5 m. One half of the plot was weedy and the remaining one half was kept weed free throughout the growing season with hand weeding. Barnyard grass, foxtail, lamb's-quarters, pigweed and wild mustard were prominent weeds in the experimental site.

Table 1. Effect of cultivars, seeding rate and row spacings on white bean yield

Cultivar (C)	Weed Treatment (W)	Planting Pattern (P) Wide row x Normal Popln.	Medium x High	Medium x Normal	Narrow x High	Narrow x Normal	Cultivars Means
		Yield kg/ha					
OAC Sprint	Weedy	401.85	697.075	545.45	688.25	650.15	1593.695
	Weed free	2683.40	2552.5	2598.35	2584.675	2535.25	
OAC Gryphon	Weedy	424.45	891.325	706.275	993.425	923.42	1854.52
	Weed free	2986.875	2870.95	2864.2	2927.1	2957.5	
OAC 87-2	Weedy	458.875	652.725	674.5	717.525	700.875	1854.52
	Weed free	2635.95	2509.425	2538.575	2830.575	2687.225	
		Pattern x Weed Means					
	Weedy	428.392	747.042	642.075	799.733	758.05	
	Weed free	2768.741	2644.292	2667.042	2780.783	2726.658	

White bean yield was adversely affected by the presence of weeds (Table 1). White beans grown with the recommended practice of wide rows and at normal populations was not different in yield from the non-conventional practices under weed free conditions. However, conventional practice resulted in lower yield under heavy weed pressures. An analysis of yield indicated that white beans grown at recommended row widths and seeding densities resulted in significantly less yield than those grown under medium or narrow spacings under weedy conditions. White bean cultivar OAC Gryphon consistently produced significantly higher yields under all row widths and seeding rates. Under weedy conditions, cultivar OAC Gryphon, when grown in narrow rows at both normal or high population or medium row width at high plant population yielded significantly better than other cultivars tested.

26. **STOKES, P.M. and D. WHELPDALE - Data analysis and interpretation of pesticide concentrations in lichens from 45 sites in Ontario (the Upper Great Lakes Basin).**

The objectives of this study were to determine the feasibility of using lower plants as monitors of trace contaminants, including pesticides and other organics, as well as sulphur and some other trace elements, from precipitation. There were three sources of funding during the first two years, with approximately equal contributions from the Atmospheric Environment Service (AES) of Environment Canada, the Ontario Pesticides Advisory Committee, and the Wildlife Toxicology Fund. During this third year, a small amount of funding for data processing and completion of organics analysis, was obtained from the two former agencies.

The study continued from collections of lichen and moss at 40 sites during 1986, to more intensive collection at fifteen of the same sites in 1987. The objective of the intensive sampling was in part to investigate the source of variability within sites, which had been observed for a number of elements as well as for some of the organic contaminants during the analysis of 1986 collections. It was felt that some of the variability might be related to analytical problems, either with the composition of the matrix or from unsatisfactory digestion procedures. Alternatively, there might have been contamination during collections.

The following elements and groups of compounds were determined in all of the samples for 1987:

Organochlorine pesticides and related compounds:- Chlordanes, toxaphenes, aldrin, dieldrin and endrin, DDE and DDT, hexachlorobenzene, alpha- and gamma-HCH, and 30 PBC congeners.

Polycyclic aromatic hydrocarbons:- naphthalenes, phenanthrene, fluoranthrene, pyrenenaphthalene, benz(a)anthranene, benz(a)pyrene.

Elements, including crustal elements as well as those expected to be present as contaminants:- cadmium, copper, lead, zinc, aluminum, boron, calcium, iron, magnesium, manganese, phosphorus and sulphur.

All of the above were detectable and measurable in at least 50% of the samples of the lichen *Cladina rangiferina*. None of the *Sphagnum* moss samples for 1986 and 1987 have been prepared or analyzed to date.

In order to check on the accuracy and precision of the determination of the elements, we used three different methods, and where possible, compared the data for the same elements measured by two or three different methods. The methods were: inductively coupled plasma emission spectroscopy and neutron activation analysis. Standard certified value reference materials were used to check on accuracy, but there was no such material from a lichen or a fungal tissue, so plant tissues had to be used. For

the organics, which were analyzed at the Dept. of Fisheries and Oceans' laboratory in Winnipeg, the laboratory used only one method, but we included additional replicates and subsamples of lichens within defined sites.

In general, when we take all possible precautions to remove sources of error, the variability remains quite large. Within-site coefficients of variation range from less than 10% to more than 60%. Certain elements (e.g., copper) and compounds (e.g., most of the polycyclic aromatic hydrocarbons, PAH's) show very high coefficients of variation, while other elements (e.g., sulphur) and compounds (e.g., DDT and its derivatives) have acceptable variation. Even with the variability discussed here, the first set of statistical analyses that have been done on the 1986 data indicate a substantial number of between-site differences for the organic compounds, particularly for the pesticides. With the exception of certain trace metals, our lichens have lower values of most contaminants than do lichens from other parts of the N. Hemisphere except for the Canadian Arctic and the Antarctic. Between year agreement is good for most of the organics. The analysis is incomplete as yet, although we have reached the end of our funding year. This is due in part to the fact that we have only just received the last set of organics data from the Winnipeg laboratory (the work was quite a new challenge for the analysts, because of the low concentrations of a number of the compounds), and in part to the fact that we ran far more inorganic analyses than we had originally planned.

We judged it essential to spend additional time and money on the technical checks outlined above, in order to be sure of the quality of the data before proceeding into numerical analysis. There is now an enormous and unique data set for organics in lichens, and a larger but not unique set for the elemental analyses. These lend themselves to a number of possible statistical treatments. We have a mapping programme available on the computer, which will enable us to present the data visually in an effective manner.

27. **WEINBERGER,P.** - **The role of algal cytochrome P-450 in determining and predicting the potential environmental hazard of xenobiotics.**

Persistence and fate-transport studies of the organophosphate insecticide fenitrothion (O,O-dimethyl-O-(3-methyl-4-nitrophenyl) phosphorothioate) have been carried out in laboratory microcosms devoid of phytoplankton. However, scattered data indicate that algae are capable of mediating photobiological transformations of chemicals (Weinberger et al., 1983, J. Environ. Sci. Health 18:269; 1982, Environ. Sci. Technol. 16:470; 1981, In Stress Effects on Natural Ecosystems, Ed. Barret & Rosenberg, J. Wiley & Sons; Zepp & Schlotzhauer, 1983, Enviorn. Sci. Technol. 17:462).

This study was initiated to determine the effects of the algal species Chlamydomonas segnis (Ettl) on the aquatic fate and persistence of fenitrothion. Using Vita Lite^{R} fluorescent lamps, the rates of fenitrothion degradation in media with live and freeze-killed algae were compared with fenitrothion degradation in media only.

Under Vita Lite^{R} lamps, fenitrothion levels in the media with live algae decreased in a first order reaction and had a rate constant of 0.43E-01 hr^{-1} (Figure 1). Fenitrothion in media alone showed a first order reaction and decreased with a rate constant of 0.22E-01 hr^{-1}. The $t^{1/2}$ of the fenitrothion significantly decreased from 30.7 hours to 16.1 hours when live algae were present in the media. When freeze-killed algae were combined with fenitrothion in the media, the same phenomena was observed, although at a reduced level. Under Vita Lites^{R}, fenitrothion decreased at a rate constant of 0.24E-01 hr^{-1} resulting in a $t^{1/2}$ of 29.1 hours (Figure 3). (The control of media only showed a degradation of fenitrothion with a rate constant of 1.5E-2 hr^{-1} and a $t^{1/2}$ of 45.8 hours).

Under dark conditions, fenitrothion decreased from the media slowly without any significant differences between media with and without live algae (rate constants of 0.76E-02 hr^{-1} and 0.49E-02 hr^{-1}, and $t^{1/2}$'s of 91.5 and 140.1 hours, respectively (Figure 2)). Fenitrothion with freeze-killed algae under dark conditions decreased with a rate constant of 0.39E-02 hr^{-1} and had a $t^{1/2}$ over 150 hours (Figure 4). (The fenitrothion in media only controls decreased with a rate constant of 0.44E-2 hr^{-1} and had a $t^{1/2}$ of over 150 hours).

Results from the first year of the study indicated a significant accumulation of ^{14}C ring labelled pesticide in both live and freeze-killed algae under light conditions even when chlorosis of photosynthetic pigments was observed by 15 hours (P. Weinberger, 1987, 'A new factor to consider in pesticide fate-transport studies' in Pesticide Research Projects, 1986-1987, The Ontario Pesticides Advisory Committee). Subsequent analysis of the ^{14}C ring label compound in the algae by TLC revealed the accumulated pesticide to be polar metabolites of fenitrothion, most likely carboxyfenitrothion and/or carboxyfenitrooxon.

Chlamydomonas segnis had a substantial effect upon fenitrothion degradation under light conditions. Metabolism of fenitrothion was enhanced by the presence of both live and freeze-killed algae, resulting in shorter $t^{1/2}$'s of the pesticide. The most uptake and metabolism occurred in live algae where no chlorosis took place, signifying the capability of chlorophyll pigments to photosensitize a photolytical pesticide such as fenitrothion.

28. GRACE, J.K., J. IRIAH and M.H.ZOBERI - **Evaluation of the use of termite attractants to synergize soil pesticide applications in structural pest control.**

The eastern subterranean termite, Reticulitermes flavipes (Kollar), is a serious pest of structures in southern Ontario, and is controlled by the application of pesticides to the soil. The purpose of this study is to evaluate the potential for integrating behaviour-modifying chemicals with soil pesticides to reduce the amount of pesticides that must be applied for control. Objectives for the first year are to (1) develop termite collection and behavioural bioassay techniques, (2) identify plants or fungi which may attract or aggregate foraging termites, and (3) extract and bioassay behaviourally active compounds.

Collection of termites and possible sources of behavioural chemicals began in June 1988 at field sites in Toronto, and Scarborough. Collections were also initiated at Kincardin later in the summer. Initially, white pine stakes (ca. 1.5 x 4 x 15 cm), each sheathed in a layer of moistened corrugated paper to aggregate termites, were placed throughout these sites (1158 in Scarborough, 461 in Toronto). Stakes were monitored at 1-2 week intervals. Where termite feeding was found, the stake was replaced by a collection trap, with adjacent traps installed no closer than two metres. These collection traps allowed nondestructive sampling of termite populations. The traps consisted of two 15 cm lengths of 4 cm ID plastic (ABS) pipe containing rolled corrugated paper, both placed within a 15 cm length of 10 cm ID pipe. This larger pipe was buried vertically just below the soil surface and the top capped. The outer pipe thus represented a permanent trap installation, while the two inner pipes could be readily removed and replaced.

Collection traps contained as many as 7,622 termites. These were maintained on corrugated paper and filter paper (Whatman No. 1) in the laboratory in plastic containers within an unlighted temperature (27 +/- 0.5^{o} C) and humidity (90 +/- 5% RH) controlled cabinet. Termites, soil carried into the traps by termites, the paper in the traps, and wood at the field sites were cultured on the following natural media: malt extract agar, potato dextrose agar, nutrient agar, bacto yeast malt extract agar, starch agar, agar agar, cellulose agar, and filter paper malt extract agar.

Wood decayed by the brown-rot decay fungus Gloeophylum trabeum (Pers. ex

Fr.) Murr is reported to produce compounds, including (cis, cis, trans) 3,6,8-dodecatrien-1-ol, that aggregate subterranean termites. In early fall, E.E. Doyle and K. Seifert of Forintek Canada Corp. (Eastern Division, Ottawa) supplied us with red pine stakes decayed by 6 weeks exposure to G. trabeum. This wood was stored at 4° C prior to extraction with various solvents. Aqueous, hexane, and dichloromethane extracts were prepared by shaking 5 g wood shavings (40-mesh) in 50 ml solvent for 15 minutes, both with heat (50° C) and at room temperature (23° C), and filtering. Three bioassays were used to evaluate these extracts: (1) a straight-line trail-following assay, (2) an assay for attractance/repellence of individual termite workers, and (3) an assay for attractance/repellence of groups of ten termite workers.

In the trail-following assay, a straight 200 mm artificial trail is drawn on tracing paper with a syringe containing 4 microliters of the test solution. A single termite worker is placed on one end of the trail, and the distance traveled in 30 seconds recorded. This assay is repeated with 25 workers per treatment. In the attractance/repellence assays, 50 microliters of solution is applied to a 2.3 cm dia. Whatman No. 1 filter paper circle. This paper is aerated for 15 min. and paired with a solvent-treated control paper in a 5 cm dia. petri dish. Either an individual R. flavipes worker or a group of ten workers is placed in the dish and their positions recorded every 30 sec. for 20 minutes. Fifty individuals are tested in the individual assays, and 20 replicates in the group assays.

Table 1 lists genera of fungi isolated from field-collected materials. Species identifications are in progress, and solvent extractions and laboratory bioassays with selected isolates will follow.

Preliminary bioassays with the aqueous, hexane, and dichloromethane extracts of decayed red pine indicated that all were active in inducing trail-following behaviour. However, a time-series with the aqueous extract indicated that the orientation component was lost fairly rapidly (Table 2). This was consistent with the results of the attractance/repellence assays. As growth of microorganisms was rapid in the aqueous extract, we are currently concentrating on dichloromethane extracts.

Addition of antioxidants has been shown to prolong the field life of insect pheromones. Although the antioxidant BHA inactivated the dichloromethane decayed-wood extract, preliminary time-series assays with BHT added to the extract (1 mg/ml and 10 mg/l) were promising (Table 3). In the coming months we will continue work on approaches to stabilizing the active compound(s). We are also developing laboratory assays using a soil matrix to more closely approximate field conditions. In anticipation of the second year of this project, we have arranged to obtain samples of three pesticides currently used in soil treatments in North America (chlorpyrifos, isofenphos, and disodium octaborate tetrahydrate) to assay in combination with the attractant extracts.

(chlorpyrifos, isofenphos, and disodium octaborate tetrahydrate) to assay in combination with the attractant extracts.

Table 1. Fungi isolated from termites, termite-infested wood, paper from collection traps containing termites, and soil carried into pipes within collection traps by termites.

Genera	No. of species
Mucorales	
Mucor	5
Cunninhamella	1
Absidia	1
Pirella	1
Rhizopus	1
Circinella	2
Actinomucor	1
Hyphomycetes	
Aspergillus	4
Penicillium	2
Trichoderma	3
Cephalosporium	1
Alternaria	1
Arthrobothrys	1
Gliomastix	1
Unidentified	3
Dictyosteliales	
Dictyostelium	1
Actinomycetes	
Unidentified	1
Unidentified	3

Table 2. Mean distances traveled by 25 *R. flavipes* workers on 200 mm artificial trails drawn with 4 µl of an aqueous extract of *G. trabeum* decayed pine.

Aeration Time	Distance (mm ± SD)
0.5 min	160.56 ± 47.56
15.0	97.24 ± 76.93
30.0	58.76 ± 52.99
45.0	30.44 ± 35.20
60.0	41.44 ± 38.71
24 hours	3.56 ± 5.54
Solvent Control	8.52 ± 12.05

Table 3. Mean distances traveled by 25 *R. flavipes* workers on 200 mm artificial trails drawn with 4 µl of a dichloromethane extract of *G. trabeum* decayed red pine.

Treatment	Distance at Different Aeration Times (mm ± SD) 15 min	45 min	75 min
extract	47.48±57.39	30.08±30.78	17.04±27.20
extract + 1mg/ml BHT	44.88±47.66	30.20±40.45	23.12±19.16
extract + 10mg/ml BHT	32.36±47.47	48.20±40.70	8.12±12.62
extract + 1mg/ml BHA	2.48± 6.25		
extract + 10mg/ml BHA	0.00± 0.00		
solvent control	3.12± 4.38		
solvent + 1mg/ml BHT	0.00± 0.00		
solvent + 10mg/ml BHT	1.52± 3.79		
solvent + 1mg/ml BHA	0.72± 3.60		
solvent + 10mg/ml BHA	4.40±16.09		

29. STROM K.B. and SANDRA M. SMITH - The potential for using egg parasitoids such as Tricogramma spp to control epidemic populations of the forest tent caterpillar in Ontario.

This paper summarizes results and progress, to date, for the study of egg parasitoids of the forest tent caterpillar (FTC), Malacosoma disstria Hbn.. The 3 main objectives of the study are: 1) to determine the FTC oviposition period and thus, the susceptible period for egg parasitism; 2) to determine the diversity, distribution and abundance of parasitoid species attacking eggs of FTC on hardwood stands in Ontario; and 3) to determine the acceptability of FTC eggs to parasitism by Trichogramma minutum Riley under laboratory conditions.

Field work for Objective 1 began in June 1988 near Six-Mile Lake, Ontario. The experimental area contained mixed deciduous stands of oak, maple, aspen and white pine common to the Muskoka's hummocky shield terrain. On-site records were taken each day of maximum/minimum temperatures and humidity (Graph 3). Temperatures ranged between a minimum of -4^{o} C to a maximum of 33^{o} C. The pattern and time of adult emergence (male moths) was determined over the field season using 6 pheromone traps set out in individual trees at ca. 2 m above ground (Graph 1). Male moths were collected between 28 June and 20 July with peak emergence observed on 4 July. A single branch sample was taken from the mid-to upper crown of 50 oak trees (predominately white oak) each day in order to determine FTC oviposition (Graph 1). Peak oviposition occurred between 8 and 10 July and corresponded with peak maximum temperatures. At the end of the field season, the population density for FTC at this site averaged 20 egg masses/branch.

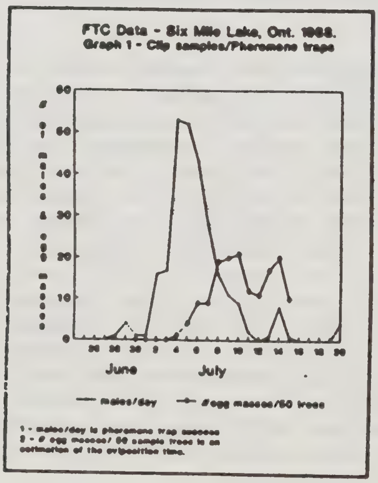
A field experiment was set up to examine the precise number of days required for oviposition based on individual egg masses. In June, 600 pupae were collected and put inside collection trays with screened lids. These trays were than placed on the ground inside a screened tent which was erected over a young white oak tree (ca. 2 m high). Adult FTC which had emerged in the trays were released once every 24 h into the enclosed tent for mating and oviposition. Only 15% of the pupae collected in the trays emerged successfully during 1988. From these 89 adults, only 4 egg masses were obtained (Graph 2). Potential causes for such poor oviposition include high levels of pupal parasitism, high temperatures during 1988, particularly on the knoll where the tent was located, and most importantly, the later emergence of female FTC relative to male moths (eg. 2-3 days after the males). The very high temperatures and ubiquitous predators (eg., stink bugs) in the screened tent may have caused rapid adult mortality following emergence and this could only have exacerbated the discordancy of male and female emergence times and resultant mating success.

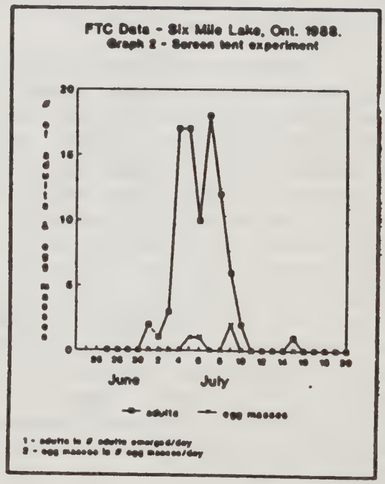
The sampling procedure for Objective 1 will be replicated during June/July 1989 to verify the shape and relative timing of the curves under

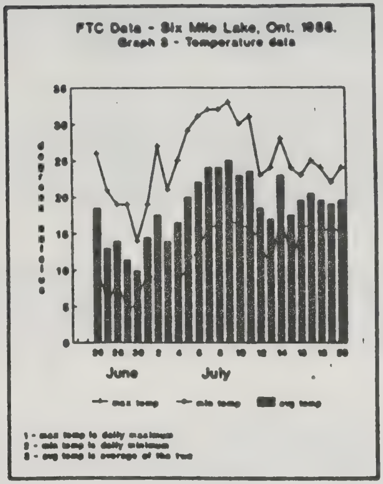
possibly different weather conditions. This will allow us to make predictions on egg-laying with respect to pheromone catch in order to forecast susceptible periods for egg parasitism.

The field work for Objective 2 began in early October 1988. The plots were located at Six-Mile Lake, Silent Lake (south of Bancroft) and Temagami. These areas were selected on the basis of similar stage of FTC outbreak (3rd year after initial infestation) and diversity of forest type. The stands were comprised of mixed deciduous species with a dominant preferred host tree selected at each site (eg., white oak at Six-Mile Park; trembling aspen at Temagami and Silent Lake). A transect of 300m was set out at each of the 3 sites. Ten plots (10 by 5 m) were identified along each transect (ca. 25 m apart). Basic stand descriptions were made on each of these 10 plots including height, composition, diameter at breast height and crown cover.

Five egg masses were collected from branch samples taken in the mid- to upper crown of trees on each of the 10 plots. The egg masses were returned to the laboratory where they are currently being held at 2 $^{\circ}$ C for a period of 3 months to break diapause. Following this overwintering period, parasitoids emerging from the egg masses will be identified and analysis carried out to determine the relative diversity, abundance and distribution of species. Rearing of FTC to address Objective 3 of the study will be initiated in January.







30. HALL, J.C. - Development of enzyme immunoassays and radio immunoassays using polyclonal and monoclonal antibodies for the detection of herbicidal residues

Funds for this research were only awarded February 15th, 1989. Therefore, a summary of progress is expected to be presented in the next research report.

APPENDIX IV : PUBLICATIONS RELATING TO THE ONTARIO PESTICIDES ADVISORY COMMITTEE RESEARCH PROGRAM

A) RESEARCH

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FRANKENHUZEN, K. and C.W. NYSTROM. 1989. Residual toxicity of a high potency formulation of Bacillus thuringiensis to spruce budworm (Lepidoptera: Tortricidae). J. Econ. Ent. 82: in press.

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GRACE, J.K. 1989. Habituation in termite orientation response to fungal semiochemicals. Sociobiology: in press.

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MADDER, D.J. and M. STEMEROFF. 1989. The feasibility of integrated pest management on potatoes in Ontario. 1985. The Ontario Pesticides Advisory Committee. ISBN No. 0-7729-5775-4. 89 pp.

NEALIS, V.G. and T.J. LYSYK. 1988. Sampling overwintering jack pine budworm, Choristoneura pinus pinus Free. (Ledidoptera: Tortricidae), and two of its parasitoids (Hymenoptera). Can Ent. 120: 1101-1111.

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STEMEROFF, M. and D.J. MADDER. 1989. A study of the costs and benefits of the research and extension associated with the integrated pest management program on apples in Ontario. 1985. The Ontario Pesticides Advisory Committee. ISBN No. 0-77294996-4. 39 pp.

WANG, T. and J.E. LAING. 1989. Diapause termination and morphogenesis of Holcothorax testaceipes Ratzeburg (Hymenoptera: Encyrtidae), an introduced parasitoid of the spotted tentiform leafminer, Phyllonorycter blancardella (F.) (Lepidoptera: Gracillariidae). Can. Ent. 121: 65-74.

B) MISCELLANEOUS

ANON, 1989. U. of G. Research: Natural way to control flies. Elora Express. June 21/89.

CRABBE, MARILYN, 1989. Feathered fly control. The search for a better mousetrap continues, but in Ontario, researchers may have found its fly-catching counterpart. Dairy Guide. June 1989.

CUNNINGHAM, J.C., W.J. KAUPP, and G.M. HOWSE. 1988. Experimental aerial application of Disparvirus for control of gypsy moth in Ontario. 16th Annual Forest Pest Control Forum. Forestry Canada, Ottawa. pg 299-311.

GRACE, J.K. 1988. Update on eastern subterrean termites. Proc. Can. Wood Preserv. Assoc. 9: 56-57.

GRACE, J.K. 1988. Development of an integrated control program for the eastern subterranean termite: annual report, 1 January-31 December 1988. Faculty of Forestry, University of Toronto. 44 pp.

HALL, J.C., R. DESCHAMPS, and M.R. McDERMOTT. 1989. Immunoassays for detecting pesticides in the environment. Highlights of Agricultural Research in Ontario 12(2): 19-23.

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